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THEA FOSS AND WHEELER-OSGOOD WATERWAYS REMEDIATION PROJECT

YEAR 12 MONITORING LONG-TERM MONITORING PLAN EVENT REPORT

NOVEMBER 16, 2018

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY

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1.0 Introduction

This document presents a summary of the long-term monitoring activities performed in 2018 (Year 12 post-construction) for the Thea Foss and Wheeler-Osgood Waterways Remediation Project Site (the Site) located in Tacoma, Washington. A project location map is presented in Figure 1-1. The Year 12 monitoring activities were performed in accordance with the *Thea Foss and Wheeler-Osgood Waterways Remediation Project Long-Term Monitoring Plan* (LTMP; City of Tacoma 2018). The LTMP is an integrated program designed to continue to evaluate the effectiveness of the remedial action relative to the project Remedial Action Objectives (RAOs) and to identify potential sources of recontamination to the Site.

Remediation construction was completed at the Site in 2006 by the City of Tacoma (City) under a Consent Decree (CD) issued by the U.S. Environmental Protection Agency (EPA) and as described in the *Remedial Action Construction Report* (RACR; City of Tacoma 2006a). The remedial actions constructed by the City in the Thea Foss and Wheeler-Osgood Waterways are summarized in Table 1-1 and illustrated on Figure 1-2. The six technologies implemented to remediate the waterways included: no action, natural recovery, enhanced natural recovery, dredged to clean, dredged and backfilled, and capping. The St. Paul Waterway Confined Disposal Facility (CDF) was also constructed as part of the remedy to contain the material dredged from the waterways. Additionally, multiple shoreline habitat enhancements and habitat mitigation sites were constructed to mitigate for habitat impacts resulting from the remedial actions and slope rehabilitation occurred on select slopes to provide more suitable habitat.

Following remediation construction, the City completed 10 years (2006 to 2016; baseline to Year 10) of post-construction monitoring and maintenance under the *Operations, Maintenance, and Monitoring Plan* (OMMP; City of Tacoma 2006b) and the *St. Paul Waterway Confined Disposal Facility Performance Monitoring Plan* (City of Tacoma 2009a). The data collected from the 10 years of post-construction monitoring under the OMMP was then used to develop the scope of monitoring activities required under the LTMP that covers monitoring activities between 2018 and 2028 (Year 12 to Year 22). The LTMP describes physical and chemical monitoring to be completed in the City's work area within the Site and sets forth specific performance standards for planned physical and chemical monitoring activities to demonstrate that the long-term objectives for the project are met. The LTMP also details the process for contingency planning and presents possible response actions in the event that performance standards are not achieved.

This Year 12 LTMP Monitoring Event Report presents the final information and data for the monitoring activities completed in Year 12 and documents any decisions and/or actions taken or recommended based on the comprehensive Year 12 monitoring results. This report also provides information to support EPA's preparation of the next 5-Year Review Report, scheduled for 2019.

1.1 SCOPE OF THE YEAR 12 LTMP MONITORING EVENT

The following long-term monitoring activities were performed in Year 12 in accordance with the LTMP:

- Chemical performance monitoring and bioassay testing in select natural recovery and enhanced natural recovery areas to continue the evaluation of the long-term effectiveness of this remedial action in these areas;
- Cap integrity monitoring through low-tide slope cap inspections and subtidal hydrographic surveys to ensure that the sediment caps remain intact;
- Waterway source contaminant monitoring of surface sediments throughout the waterways to evaluate the potential for recontamination, including recontamination from urban and waterway operational contributions;
- Monitoring of groundwater and surface water quality and cap and berm conditions at and in the vicinity of the CDF, to ensure the contaminated dredged sediments are effectively contained in the disposal facility; and
- Monitoring in habitat mitigation/restoration areas to evaluate habitat conditions established within the project area.

Table 1-2 provides a summary of these monitoring activities and the monitoring years in which these activities are performed under the LTMP.

1.2 LONG-TERM MONITORING COSTS

As required by the CD/SOW, a brief summary of the long-term monitoring costs is provided below and in Table 1-3.

Year 12 LTMP monitoring activities began in March 2018 and will be ongoing through the approval of this Year 12 LTMP Monitoring Event Report. Floyd|Snider is assisting the City with performance of the Year 12 monitoring activities as well as the reporting of the results. In addition, David Evans and Associates performed the hydrographic survey work required for the Year 12 subtidal cap integrity monitoring. The total cost for the Year 12 monitoring work, including both internal City costs, laboratory costs, and consultant costs is $244,000. Projected costs for Year 17 and Year 22 are estimated at $250,000 for each of these scheduled LTMP monitoring events.

1.3 ORGANIZATION OF THE LTMP MONITORING EVENT REPORT

The organization of the Year 12 LTMP Monitoring Event Report follows the same outline as the LTMP to provide a consistent presentation and placement of information generated for the Site's long-term monitoring activities. The Monitoring Event Report is organized into the following sections:

- Section 1.0 – Introduction
- Section 2.0 – Remedial Area Monitoring
- Section 3.0 – Waterway Source Monitoring
- Section 4.0 – Confined Disposal Facility Monitoring
- Section 5.0 – Habitat Mitigation/Restoration Area Monitoring
- Section 6.0 – References

Each section of the Year 12 LTMP Monitoring Event Report is divided into subsections that describe the long-term monitoring objectives and rationale, the monitoring requirements, the specific monitoring activities performed in Year 12, the Year 12 monitoring findings, and a summary of the Year 12 monitoring conclusions and the next steps planned for future long-term monitoring. This Year 12 LTMP Monitoring Event Report is supported by appendices that include Preliminary Findings Memorandums (PFMs) prepared for each Year 12 LTMP monitoring activity and the Year 12 Performance Monitoring Memorandum for the St. Paul CDF. These PFMs and the Performance Monitoring Memorandum contain more detailed summaries of the monitoring activities performed and analyses of the monitoring data. Additionally, these PFMs and the Performance Monitoring Memorandum contain supporting field documentation and data reports from the Year 12 monitoring activities as attachments.

Two additional monitoring activities, including a supplemental grout mat inspection in Remedial Area (RA) 3 and sheen sampling in two of the slope rehabilitation areas, were performed in Year 12 based upon the preliminary findings from the Year 12 monitoring activities. The field documentation and data reports from these additional monitoring activities are included as appendices in this Year 12 LTMP Monitoring Event Report.

2.0 Remedial Area Monitoring

A total of six technologies were implemented to remediate the Thea Foss and Wheeler-Osgood Waterways. These technologies included: no action, natural recovery, enhanced natural recovery, dredged to clean, dredged and backfilled, and capping. The LTMP remedial area monitoring program, described in Section 2.0 of the LTMP, determined that some of the remedial areas where these technologies were applied required no further long-term monitoring as the RAOs had already been achieved in these areas. The areas where no long-term remedial action monitoring was required as part of the LTMP included the no action, dredged to clean, and dredged and backfilled areas (refer to Figure 1-2). Under the LTMP, long-term remedial area monitoring was required in the capped areas of the waterways to continue to evaluate the long-term effectiveness of the sediment caps. Additionally, the LTMP required that focused monitoring in the natural recovery and enhanced natural recovery areas be performed in Year 12 to further evaluate compliance with the RAOs.

The long-term remedial area monitoring activities required by the LTMP and performed in Year 12 included:

- Physical inspections of the cap areas to ensure that the engineered caps remain intact. The physical inspections performed included a hydrographic survey of the subtidal caps and low-tide inspections of the intertidal caps.
- Focused chemical and bioassay testing of surface sediments within four natural recovery areas and one enhanced natural recovery area that had ongoing bis(2-ethylhexyl)phthalate (DEHP) Sediment Quality Objective (SQO) exceedances after 10 years of monitoring.

The following sections are organized by the type of remedial technology applied and describe what, if any, long-term monitoring was required under the LTMP. In the remedial areas where long-term remedial area monitoring was performed in Year 12, a summary of the monitoring requirements, activities, and findings from Year 12 is provided. Section 2.7 provides a summary of the Year 12 remedial area monitoring conclusions and a brief discussion of future long-term remedial area monitoring under the LTMP.

2.1 NO ACTION AREAS

RAOs have been achieved and no long-term monitoring is required in the no action areas as part of the LTMP.

2.2 NATURAL RECOVERY AREAS

The natural recovery areas are areas that were not designated for active remedial action because they were expected to have contaminant concentrations recover to less than the Commencement Bay SQOs through natural sedimentation, mixing, and other processes within

10 years of completion of the remedial action. Following 10 years of natural recovery monitoring under the OMMP (baseline to Year 10), the SQOs were achieved at all of the natural recovery stations, with the exception of DEHP at four stations. The Year 10 DEHP results from these four natural recovery stations did not meet the DEHP SQO or the Sediment Management Standards (SMS) sediment quality standard (SQS) for DEHP. These four natural recovery sample station locations are shown on Figure 2-1. In Year 12, natural recovery monitoring was performed at these four stations in accordance with the LTMP to determine whether these sediments had achieved compliance with the DEHP SQO or SQS criteria. Any Year 12 samples with DEHP concentrations greater than both the SQO and SQS criteria were then required to undergo biological toxicity (bioassay) testing to further assess compliance.

Following the Year 12 natural recovery monitoring field work, chemical analyses, and bioassay testing, a *Year 12 Natural Recovery and Enhanced Natural Recovery Monitoring PFM* (Natural Recovery and Enhanced Natural Recovery PFM) was prepared that detailed the LTMP natural recovery monitoring requirements, the Year 12 field activities, analytical results, and bioassay testing results, and the preliminary findings of the Year 12 natural recovery monitoring. This Natural Recovery and Enhanced Natural Recovery PFM is included as Appendix A. This section presents a summary of the Year 12 natural recovery monitoring.

2.2.1 Natural Recovery Monitoring Requirements

The LTMP natural recovery performance monitoring program was designed to determine whether compliance with the SQOs has been achieved. The required activities included in this monitoring are discussed in this section.

Per the LTMP, natural recovery monitoring would be conducted at four stations (Stations NR-07, NR-11, NR-12, and NR-20) in Year 12 (refer to Figure 2-1). The natural recovery surface sediment (0 to 10 cm) samples collected from these stations would be analyzed for DEHP, total organic carbon (TOC), total solids, and grain size. Additionally, porewater from these sediment samples would be analyzed for ammonia and total sulfides to inform the bioassay testing process and results interpretation, if required, in accordance with guidance provided in the Sediment Cleanup User's Manual II (SCUM II; Ecology 2017). During the sampling, sufficient sediment volume to perform bioassay testing also would be collected at these four stations, if determined necessary. Reference surface sediment samples (0 to 10 cm) for the bioassay testing would be collected from Carr Inlet and a rapid grain size analysis performed to provide an initial match of reference sediments with that of the sample sediments. These reference samples collected and selected for use would be analyzed for TOC, total solids, grain size, and porewater ammonia and total sulfides.

The DEHP results from the sediment samples would be compared to the SQO and SQS criteria for DEHP. Although the SQO for DEHP (1,300 micrograms per kilogram [µg/kg]) is the established performance standard for the Thea Foss and Wheeler-Osgood Waterways, it was determined in coordination with EPA that DEHP also would be evaluated relative to compliance with the SMS

SQS for DEHP as part of the LTMP monitoring. The current DEHP SQS is organic carbon (OC) normalized and is set at 47 milligrams per kilogram (mg/kg)-OC. To evaluate compliance with the DEHP SQS, the dry-weight DEHP concentrations for the samples would be OC-normalized using sample-specific TOC results.

Sediment samples that exceeded both the DEHP SQO and SQS criteria would have bioassay testing conducted, which consists of a sediment larval test, an amphipod bioassay, and a juvenile polychaete bioassay. The bioassay testing results would be compared to the SMS sediment cleanup objective (SCO) and the cleanup screening level (CSL) biological criteria to identify sediments that have no adverse effects on biological organisms.

In accordance with the LTMP, if the DEHP sediment concentrations at any station are less than the DEHP SQO or SQS, then no further sampling would be required at that station during future LTMP monitoring events. Additionally, if the DEHP sediment concentrations were greater than the DEHP criteria, but the bioassay tests passed, no further sampling at those stations would be required during future monitoring events.

More detailed natural recovery monitoring requirements are provided in the Natural Recovery and Enhanced Natural Recovery PFM and Sediment Sampling Operations Manual in the LTMP.

2.2.2 Summary of Year 12 Natural Recovery Monitoring Activities

The Year 12 natural recovery monitoring was conducted at all four sample stations on June 4 and 5, 2018. Enhanced natural recovery monitoring was also conducted at one sample station during the natural recovery monitoring work and is described in Section 2.3. Sample collection forms and photographs documenting activities and observations during the sampling event are presented in Attachment A of the Natural Recovery and Enhanced Natural Recovery PFM (refer to Appendix A). Natural recovery monitoring samples were designated by NR, followed by the sample station number, and then the monitoring year (e.g., NR-07-Y12). The Year 12 samples (0 to 10 cm) were discrete grabs collected using a Van Veen sampler deployed from the City's vessel. One field duplicate (sample NR-11-Y12-2), a duplicate of sample NR-11-Y12, was collected during the monitoring event.

The natural recovery monitoring samples were submitted to the City laboratory under approved sampling handling and chain-of-custody procedures. The City laboratory conducted the TOC, total solids, and DEHP analyses; Materials Testing and Consulting, Inc., laboratory conducted the grain size analysis; and Analytical Resources, Inc., laboratory conducted the porewater ammonia and sulfides analyses.

Three reference sediment samples were collected in various locations within Carr Inlet to represent the range of different grain sizes present in the Year 12 monitoring samples collected. The reference sediment samples were designated by CIR, followed by a sample number, and then the monitoring year (e.g., CIR-01-Y12). Each of the reference samples were discrete surface sediment grabs (0 to 10 cm) collected using a Van Veen sampler deployed from Research Support Services' vessel. A wet sieve was used in the field to determine the percent fines in each of the reference samples prior to collection. Rapid wet sieving results for samples CIR-01-Y12, CIR-02-Y12, and CIR-03-Y12 showed approximately 57 percent fines, 24 percent fines, and 91 percent fines, respectively. These reference sediment samples were analyzed for TOC, total solids, grain size, porewater ammonia, and sulfides.

Data validation was performed on the laboratory analyses for the monitoring and reference samples in accordance with the LTMP. No qualifiers were added to the analytical results based on the data quality review. Data were determined to be of acceptable quality for use as reported by the laboratory. The data validation reports for these samples are included in Attachment B of the Natural Recovery and Enhanced Natural Recovery PFM.

Based on exceedances of the DEHP SQO and SQS criteria in two of the natural recovery sediment samples (samples NR-11-Y12 and NR-20-Y12), as discussed in Section 2.2.3, these two sediment samples were submitted to Northwestern Aquatic Sciences for bioassay testing. Reference samples CIR-02-Y12 and CIR-03-Y12 were also submitted to Northwestern Aquatic Sciences for bioassay testing. Based on the grain size analysis, sample NR-11-Y12 was matched with reference sample CIR-03-Y12 and sample NR-20-Y12 was matched with reference sample CIR-02-Y12 to ensure that the difference in percent fines between the reference and test sediments did not exceed 20 percent. The bioassay data underwent data quality review upon completion of the tests and are presented in the bioassay testing report (Attachment C of the Natural Recovery and Enhanced Natural Recovery PFM).

2.2.3 Summary of Year 12 Natural Recovery Monitoring Findings

This section summarizes the findings of the Year 12 natural recovery monitoring. Table 2-1 compares the DEHP analytical results for the Year 12 natural recovery monitoring samples to the DEHP SQO and SQS criteria and summarizes which samples required further bioassay testing based on this criteria comparison. The sample results for the grain size, TOC, total solids, porewater ammonia, and sulfides analyses are provided in the Natural Recovery and Enhanced Natural Recovery PFM (Appendix A). Tables 2-2a through 2-2c summarize the results of the bioassay testing. For a detailed summary of the Year 12 natural recovery monitoring results refer to the Natural Recovery and Enhanced Natural Recovery Monitoring PFM.

The natural recovery monitoring findings include the following:

- Two of the natural recovery stations, Stations NR-07 and NR-12, had DEHP sample concentrations that were less than either the SQO or the SQS criteria. Based on these DEHP results, no bioassay testing was required on the samples from these two stations. Additionally, in accordance with the LTMP, no further sampling is required at these two stations during future monitoring events.

- Natural recovery stations NR-11 and NR-20 had DEHP sample concentrations that were greater than the SQO and SQS criteria. Because both DEHP criteria were exceeded at these two stations, bioassay testing was required on samples NR-11-Y12 and NR-20-Y12. Neither of the test sediment samples (samples NR-11-Y12 and NR-20-Y12) exceeded the SCO or CSL biological criteria (refer to Tables 2-2a through 2-2c). Based on the results of the biological testing, no further sampling is required at these two stations during future monitoring events.
- Based on the Year 12 natural recovery monitoring results, the natural recovery RAO has now been achieved at these four stations.

2.3 ENHANCED NATURAL RECOVERY AREA

The only enhanced natural recovery area present in the waterways is shown on Figure 2-1 and is located in RA 7, under a portion of the Foss Harbor Marina and directly south of the Murray Morgan Bridge (MMB). In order to facilitate enhanced natural recovery in this area, 6 inches of clean channel sand cap material was placed on the sediment surface as part of the remedial action. This area was expected to have contaminant concentrations recover to less than the SQOs through natural sedimentation, mixing, and other processes within 10 years of completion of the remedial action. During the Year 10 enhanced natural recovery monitoring in this area, performed at Station NR-16, DEHP was the only analyte that exceeded the SQO, as well as the SQS for DEHP. In Year 12, enhanced natural recovery monitoring was performed at Station NR-16 in accordance with the LTMP to determine whether these sediments are in compliance with the DEHP SQO or SQS criteria. Per the LTMP, if the sediment from Station NR-16 exceeded both of these DEHP criteria, then this sample was required to undergo bioassay testing.

The Year 12 enhanced natural recovery monitoring was completed concurrent with and similar to the Year 12 natural recovery monitoring described in Section 2.2. This section briefly summarizes the Year 12 enhanced natural recovery monitoring requirements and activities, but refers to Sections 2.2.1 and 2.2.2 for most of these details. Section 2.3.3 summarizes the findings for the Year 12 enhanced natural recovery monitoring. Refer to the Natural Recovery and Enhanced Natural Recovery PFM, included as Appendix A, for more specific details regarding the Year 12 enhanced natural recovery monitoring.

2.3.1 Enhanced Natural Recovery Monitoring Requirements

The LTMP enhanced natural recovery performance monitoring program was designed to determine whether compliance with the SQOs has been achieved. The required activities included in this monitoring are discussed in this section.

Per the LTMP, enhanced natural recovery monitoring was conducted at one station, Station NR-16, in Year 12 (refer to Figure 2-1). The requirements for the LTMP enhanced natural recovery monitoring were the same as what was required for natural recovery monitoring and are described in Section 2.2.1.

2.3.2 Summary of Year 12 Enhanced Natural Recovery Monitoring Activities

The Year 12 enhanced natural recovery monitoring was conducted at Station NR-16 on June 4, 2018. The sample collected from this station was designated NR, followed by the station number, and then the monitoring year (e.g., NR-16-Y12). The field activities and laboratory analyses performed for the enhanced natural recovery monitoring are the same as those performed for the natural recovery monitoring and these are described in Section 2.2.2.

Because the DEHP SQO criterion was met in sample NR-16-Y12, no bioassay testing was required at this station, as discussed in Section 2.3.3.

2.3.3 Summary of Year 12 Enhanced Natural Recovery Monitoring Findings

This section summarizes the findings of the Year 12 enhanced natural recovery monitoring. For a detailed summary of the Year 12 enhanced natural recovery monitoring results, refer to the Natural Recovery and Enhanced Natural Recovery PFM.

The DEHP concentration detected in the enhanced natural recovery sample from Station NR-16 was less than the SQO, while the DEHP OC-normalized concentration was just greater than the SQS criterion (refer to Table 2-1). Because the DEHP SQO criterion was met, no bioassay testing was required at this station. Additionally, with the DEHP SQO criterion met, no further sampling is required at this enhanced natural recovery station during future monitoring events per the LTMP. The natural recovery RAOs have now been achieved at this station.

2.4 DREDGED TO CLEAN AREAS

RAOs have been achieved and no long-term monitoring is required in the dredged to clean areas as part of the LTMP.

2.5 DREDGED AND BACKFILLED AREAS

RAOs have been achieved and no long-term monitoring is required in the dredged and backfilled areas as part of the LTMP.

2.6 CAP AREAS

The RAO for the caps is to provide effective containment, both physically and chemically, of underlying contaminated sediment and provide a substrate that promotes colonization by aquatic organisms. Based on the first 10 years of OMMP monitoring in the cap areas, it was concluded in the LTMP that this RAO had been achieved in both the intertidal and subtidal areas of the caps. Based on this conclusion, it was determined in the LTMP that long-term monitoring in the cap areas should continue to consist of physical integrity performance monitoring, but that no further chemical surface sediment performance monitoring or benthic recolonization monitoring would be required.

The LTMP cap physical integrity performance monitoring program is designed to detect and evaluate long-term changes in cap thickness and includes the following field activities:

- **Subtidal Cap Hydrographic Surveys.** Hydrographic surveys are performed during high tide in all subtidal slope, grout mat, and channel sand cap areas to evaluate changes (scour/erosion or deposition) in cap thickness as indicated by changes in elevation over time.
- **Low-Tide Slope Cap Inspections.** Low-tide slope cap inspections are performed to verify the physical integrity of the slope and grout mat caps in all intertidal cap areas. Monitoring activities in these slope cap areas will include a visual inspection of the slope and grout mat cap conditions to ensure that the caps are intact and coverage has been maintained (i.e., underlying contaminated sediment is not exposed).

The Year 12 monitoring requirements, activities, and findings for the subtidal cap hydrographic surveys and the low-tide slope cap inspections are described in the following sections.

2.6.1 Subtidal Cap Hydrographic Surveys

In accordance with the LTMP, subtidal cap hydrographic surveys are required to be performed during LTMP monitoring event Years 12, 17, and 22 within the cap areas shown on Figure 2-2. Multibeam hydrographic surveys are conducted during high tide in all subtidal cap areas to evaluate potential changes (i.e., loss of material) in cap thickness over time that may impact the effectiveness of the cap. The objective for hydrographic surveys is to gather sufficient data density to provide complete and comprehensive coverage to assess the integrity of the cap in terms of potential long-term changes in cap thickness within the subtidal slope cap, grout mat, and channel sand cap areas.

The Year 12 hydrographic survey was completed on March 28 and 29, 2018, by David Evans Associates, Inc., in accordance with the LTMP. A brief summary of the Year 12 hydrographic survey requirements, activities, and findings is included in the sections that follow. Refer to the Subtidal Cap Hydrographic Survey PFM (Hydrographic Survey PFM), which is included as Appendix B, for more specific details regarding the Year 12 hydrographic survey.

2.6.1.1 Subtidal Cap Hydrographic Survey Requirements

The required activities for the LTMP subtidal cap hydrographic survey program are discussed in this section.

The LTMP specifies that multibeam hydrographic surveys of the subtidal slope and channel cap areas be conducted to evaluate elevation changes (i.e., loss of material) over time that could impact the physical integrity of the cap. Subtidal cap hydrographic surveys would be performed in subtidal slope and channel cap areas up to an approximate elevation of 0 feet mean lower low water (MLLW) or to the maximum extent possible in the event of limited access due to the presence of marine structures (piers, floats, wharves, etc.). The subtidal multibeam hydrographic surveys would be performed to provide adequate coverage of the required survey area (refer to Figure 2-2) and according to the methods described in the Physical Cap Integrity Operations Manual (Appendix A of the LTMP).

Hydrographic survey results would be compared to previous survey results to evaluate apparent changes in the cap elevation over time and to identify any potential erosional areas. Hydrographic survey data would be evaluated to identify whether there are areas where a contiguous region of the cap exhibits greater than 6 inches of net erosion relative to previous surveys. A loss of 6 inches or more of cap thickness in a localized contiguous area over two monitoring events may trigger a response action.

2.6.1.2 Summary of Year 12 Subtidal Cap Hydrographic Survey Activities

As described above, the Year 12 multibeam hydrographic survey was conducted in March 2018 by David Evans Associates, Inc. The objective of the Year 12 hydrographic survey was to obtain elevation data for subtidal capped areas, defined as the capped areas within RA boundaries extending up the shoreline to a target elevation of 0 feet MLLW. The intertidal slope caps placed along the shoreline above 0 feet MLLW are visually monitored by low-tide slope cap inspections that occur when the tides are -1 foot MLLW or lower as described in the LTMP and in Section 2.6.2. This allows for some overlap in the slope cap areas being monitored during the subtidal cap hydrographic survey and the low-tide slope cap inspections.

Multibeam data were collected by running lines both parallel and perpendicular to the waterway for the length of the project. Similar to the previous hydrographic surveys, completed in accordance with the OMMP, the vessel was generally able to survey close to the shoreline. Additionally, multiple passes were performed with the survey vessel to try to acquire additional data in some areas where access was obstructed by marine structures, such as docks or boats. In general, the Year 12 survey was comprehensive, with similar or better coverage than the Year 10 survey with only a few small scattered areas where complete survey data could not be collected. Of note, there was a large boat moored in front of the former Martinac Shipyard facility in RA 14 during the survey (similar to Year 7), which limited hydrographic survey coverage in that remedial area.

The Year 12 bathymetric conditions for the sixteen RAs that have subtidal slope, grout mat, and/or channel sand caps and the MMB subtidal cap area are shown on figures included in the Hydrographic Survey PFM (refer to Appendix B).

2.6.1.3 Summary of Year 12 Subtidal Cap Hydrographic Survey Findings

The following summarizes the findings from the Year 12 hydrographic survey and compares the results to the baseline survey (or Year 2 survey, where limited baseline survey data are available) and the Year 10 survey. For a detailed summary of the Year 12 survey results and comparison to previous survey data refer to the Hydrographic Survey PFM (Appendix B). A comparison of the

Year 10 bathymetric surface to the Year 12 bathymetric surface is included in Figure 2-3. Additional comparison figures, which compare the Year 12 results to the baseline and Year 2 surveys provide additional detailed comparisons of the Year 10 and Year 12 surveys, and are included in the Hydrographic Survey PFM.

The hydrographic survey findings include the following:

- Nearly complete coverage of the subtidal slope, grout mat, and channel sand cap areas was achieved in the Year 12 hydrographic survey. There was a fairly large area that could not be surveyed in RA 14 due to the presence of a large vessel in front of the former Martinac facility.
- The Year 12 hydrographic survey was performed using equipment and procedures comparable to prior hydrographic surveys performed under the OMMP; a smaller survey vessel was used in Year 12 than in previous surveys. The use of a smaller and more maneuverable survey vessel in Year 12 provided better coverage along some shoreline slopes and, in some instances, provided coverage in areas that could not be fully surveyed during past events due to obstructions such as floats or vessels.
- In general, the Year 12 cap surface elevations are within 6 inches of the baseline surface elevation and within the allowable accuracy of the survey equipment (Refer to Figure 18 included in Appendix B).
- A comparison of the Year 10 survey to the Year 12 survey shows that the elevations in most areas have remained fairly consistent and stable during the past 2 years (refer to Figure 2-3).
- There are limited areas where the decrease in the cap surface elevation from baseline to Year 12 is greater than 6 inches but less than 1 foot. These areas are generally small, localized, and non-contiguous and do not warrant response actions.

Based on the results of the Year 12 hydrographic survey and comparison of the Year 12 survey data with the previous Year 10 data and baseline data (or Year 2 data, where limited baseline data are available), there are no proposed response actions for the subtidal cap area. Low-tide slope cap inspections were performed in June 2018, as described in Section 2.6.2, and were used to supplement the Year 12 hydrographic survey analysis in areas where complete hydrographic coverage was limited (such as RA 14). Additionally, the Year 12 low-tide slope cap inspections were used to help determine if there was an actual loss of cap material occurring in slope cap locations that showed a decrease in the cap surface elevation along the upper boundary of the hydrographic surveys areas when comparing the Year 10 and Year 12 hydrographic survey results. These evaluations are described in more detail in Section 2.6.2.

2.6.2 Low-Tide Slope Cap Inspections

In accordance with the LTMP, low-tide slope cap inspections were performed in Year 12 to evaluate the physical integrity of the slope caps in RAs 1B, 3, 8, 14, 19A, 19B, and 20 in the Thea

Foss Waterway and in the Sheen Source Removal Area in the Wheeler-Osgood Waterway. These slope cap areas are shown on Figure 2-4. Following the Year 12 inspections, a Year 12 Low-Tide Slope Cap Inspections PFM (Low-Tide PFM) was prepared that detailed the LTMP slope cap inspection requirements, the Year 12 slope cap inspection field activities, the Year 12 slope cap inspection observations and comparison to previous inspections, and the preliminary findings of the Year 12 slope cap inspections. This Low-Tide PFM is included as Appendix C. A summary of the Low-Tide PFM, focusing on the Year 12 slope cap conditions and the identified areas of the cap recommended for further evaluation or a potential response action, is provided below.

The grout mat cap in RA 3 was identified as one of the slope cap areas where a potential response action was recommended in the Low-Tide PFM. Based on this recommendation, further evaluation of the grout mat cap conditions in RA 3 was performed during a supplemental inspection that occurred on October 5, 2018. A summary of this supplemental inspection and the next steps for evaluating repair options for the grout mat is also provided in Section 2.6.2.4.

2.6.2.1 Low-Tide Slope Cap Inspection Requirements

The required activities for the LTMP low-tide slope cap inspections are discussed in this section.

Visual inspections of the exposed shoreline portion of the slope and grout mat caps would be performed to ensure that the caps are intact and coverage has been maintained. These visual inspections would be performed at approximate 100-foot monitoring intervals along the designated shoreline cap areas, as shown on Figure 2-4. Additionally, focused visual inspections would be performed in five select slope cap sub-areas within these monitoring intervals that are located in high energy/dynamic environments or in other areas previously identified with deficiencies during the Year 10 inspections. These five focused slope cap inspection areas are shown in red on Figure 2-4 and are described in Table 2-3. Standardized field forms and photographs would be used to document observations of the slope caps during the visual inspections, and for the focused slope cap inspections, more detailed observations would be made and additional documentation prepared. The visual inspections would occur when predicted tides are lower than -1 foot MLLW except in the focused slope cap inspections areas where the visual inspections would be conducted during the lowest tide levels, at approximately -2 feet MLLW to the extent practicable.

More detailed low-tide slope cap inspection requirements are provided in the Low-Tide PFM and in the Physical Cap Integrity Operations Manual in the LTMP.

2.6.2.2 Summary of Year 12 Low-Tide Slope Cap Inspection Activities

Year 12 low-tide slope cap inspections were performed in RAs 1B, 3, 8, 19A, 19B, and 20 between June 12 and 15, 2018, and in RA 14 and the Sheen Source Removal Area in the Wheeler-Osgood Waterway between June 27 and 28, 2018. These visual inspections were performed when predicted tidal elevations were at or below -1 feet MLLW. The focused visual inspections occurred when the predicted tidal elevations were at or below -2 feet MLLW with the exception of the focused inspection in the Sheen Source Removal Area that occurred at a tidal elevation of -1.5 feet MLLW, the lowest tide that occurred on June 28, 2018.

The field forms and photographs that were used to document observations of the caps during the Year 12 visual inspections are provided as Attachment A in the Low-Tide PFM (refer to Appendix C). Additionally, photographs of the slope cap areas from the baseline (Year 0) and Year 10 inspections are also provided in Attachment A in the Low-Tide PFM to allow for a comparison to the Year 12 slope cap conditions.

2.6.2.3 Summary of Year 12 Low-Tide Slope Cap Inspection Findings

This section presents a summary of the findings from the Year 12 low-tide slope cap inspections. Additionally, Table 2-3 provides a brief summary of the conditions in each of the focused low-tide slope cap inspection areas as of Year 12. For a detailed summary of the Year 12 low tide slope cap inspection observations and a comparison to previous low-tide inspections refer to the Low-Tide PFM (Appendix C).

The Year 12 low-tide slope cap inspections findings include the following:

- All slope cap areas have been evaluated for cap integrity during baseline (Year 0) and in Years 2, 4, 7, and 10 following remedial action construction in accordance with the OMMP and in Year 12 in accordance with the LTMP. In general, these slope caps have remained intact and stable over time with most areas having no observed issues regarding cap integrity between the baseline and Year 12 monitoring events.
- When comparing the Year 10 and Year 12 hydrographic survey results (refer to Figure 2-3), there were multiple slope cap locations that showed a decrease in the cap surface elevation along the upper boundary of the hydrographic surveys. These locations were present in RAs 1B, 3, 19B, and 20. These areas were all later visually inspected during the Year 12 low-tide slope cap inspections to determine if any apparent loss or erosion of material was occurring in these areas. Based on these Year 12 visual inspections, there was no apparent loss or erosion of material observed in any of these locations.
- No major deficiencies were identified upon inspection of the slope caps in RAs 14, 19A, 19B, and 20.
- For the remaining RAs (1B, 3, 8, and the Sheen Source Removal Area), various slope cap deficiencies were observed in portions of these areas. These deficiencies are summarized below and include the presence of cutoff piling and possible weathering and other natural processes on the northern portion of the shoreline in RA 1B; multiple holes in the grout mat in RA 3; exposed underlying material in two upper slope cap areas within RA 3; previous downslope movement near Outfall 230 in RA 8 noted during past inspections; the presence of multiple cutoff piling and exposed

geotextile fabric in a portion of RA 8 (Monitoring Interval RA-8-10); exposed underlying material in a slope cap area within RA 8 (Monitoring Interval RA-8-14); and sheen observed on ponded water at the base of the slope in the Sheen Source Removal Area.

- RA 1B: Two of the five monitoring intervals in RA 1B were observed to have piling ends present at the surface of the capped area (Monitoring Intervals RA-1B-4 and RA-1B-5). A total of thirteen piling ends were observed in these two monitoring intervals during the Year 12 inspection. During the Year 10 inspection, twenty piling ends were observed in these two monitoring intervals. The variation in the number of piling ends observed between the inspection years is likely attributable to these piling ends being difficult to identify as they blend in well with the riprap and slope. The piling ends do not appear to be impacting the integrity of the cap or containment of the underlying contaminated sediments.

  Additionally, significant wave action during winter storms may have caused some movement of slope cap material in the northern half of this remedial area (Monitoring Intervals RA-1B-3 to RA-1B-5) over the past 12 years of monitoring, based on multiple observations (some potential downslope movement of riprap, missing sampling stakes, changes to the surface of the habitat mix bench in places, and photo comparisons of the slope cap over time). However, the cap appears to have remained intact and the integrity of the cap does not appear to be affected in this northern half of RA 1B. This conclusion is supported by a comparison of the results from the subtidal hydrographic surveys completed over the years in RA 1B, which have shown consistent elevations in this area over time, including the most recent comparison of Year 10 and Year 12 subtidal hydrographic survey results (refer to Figure 2-3). No response action is proposed for the northern portion of RA 1B at this time; however, this portion of RA 1B will continue to be monitored as a focused slope cap inspection area during future LTMP monitoring events.

  No deficiencies were identified in the other two monitoring intervals in the southern half of RA 1B.

- RA 3: During the Year 12 inspection of RA 3, eight, and possibly nine, holes were observed on the surface of the grout mat in Monitoring Intervals RA-3-2 and RA-3-3. Five of these holes were not previously observed during the Year 10 inspection; however, the new holes observed in Year 12 are generally 2 inches in diameter or smaller. One of the holes observed during previous slope cap inspections has increased in size and is now 10 to 12 inches in diameter. This hole also extends through both layers of the grout mat fabric, with no grout visible between the fabric layers. Two of the other holes previously observed in the Year 10 inspection appeared as depressions, and not holes, on the grout mat surface during the Year 12 inspection. The size of the depressions in these two places does not appear to have increased substantially over the past two years. One of the grout mat holes is located above the apparent high water line does not appear to have increased in size over time. One previous hole observed during the Year 10 inspection was not observed during the Year 12 inspection. During both the Year 10 and Year 12 inspections, it was observed that the fabric surface of the grout mat above the apparent high water line appears to be frayed in places with the grout underneath visible but still intact, suggesting possible weathering of the fabric due to rain and sun exposure. Despite the increase in the number of holes and the increase in size of at least one of the holes over time, as well as the fraying of the fabric near the top of the grout mat, these issues do not appear to be impacting the containment of the underlying contaminated sediments at this time. However, based on the Year 12 observations of the grout mat conditions, the City elected to conduct a supplemental inspection of the grout mat to better assess the current level of damage to the grout mat and to assess possible repair options. This supplemental inspection was performed on October 5, 2018. A summary of the supplemental inspection and the proposed response based on this inspection is described below in Section 2.6.2.4.

Two areas of the upper slope cap within RA 3 have exposed underlying material present due to downslope movement of the slope cap material. One area shows exposed geotextile, approximately 4 feet long and 2 feet wide, and a small area of exposed sediment where the geotextile is pulled back. This area is located on the top of the slope above the apparent high water line and adjacent to the southern edge of the grout mat within Monitoring Interval RA-3-2. The second area shows exposed concrete material, approximately 4 feet by 5 feet in extent, with a small area of slag visible within this exposed area. This area is located at the north end of Monitoring Interval RA-3-3 on the top of the slope above the apparent high water line. The slopes are steep in these two areas and slope cap repairs were previously made in both of these areas in 2007. Potential response actions to address these two slope cap areas with exposed underlying materials are discussed in Section 2.6.2.4.

The remaining slope cap areas within RA 3 had no deficiencies identified.

- RA 8: During the Year 4 inspection at Outfall 230 in RA 8, it was observed that riprap had moved downslope of a sandy area, located below the waterline, off the mouth of the outfall. During the Year 7 inspection, this sandy area was still present, but the riprap farther downslope was not observed, suggesting that either this riprap had been covered over with sand and gravel coming out of the outfall or had moved farther downslope. In Year 10, there were no apparent changes observed in the vicinity of Outfall 230 above the waterline in comparison to the Year 7 inspection. The slope conditions off the mouth of the outfall observed during the Year 12 inspection were comparable to those observed during the Year 7 and Year 10 inspections, indicating that this area has been relatively stable over the past 5 years. Some possible downslope movement of quarry spalls on the steep slope on the southern side of the Outfall 230 splash pad was noted; however, this change appeared to be minor and the slope cap remains intact in this area. No response action is proposed for the

Outfall 230 area at this time; however, this area will continue to be monitored as a focused slope cap inspection area during future LTMP monitoring events.

In Monitoring Interval RA-8-10, seven piling ends and exposed geotextile are present near the low-tide waterline along a portion of the slope cap area. This area was first observed during the Year 4 inspection and there appeared to be some additional downslope movement of riprap near these pilings between the Year 4 and Year 7 inspections exposing additional geotextile. However, minimal additional downslope movement was apparent when comparing observations from the Year 7, Year 10, and Year 12 inspections, based on the amount of geotextile exposed on the slope and the heights of the pilings' ends above the slope cap surface. These observations indicate that this area has remained relatively stable over the past 5 years. No response action is proposed in this area and this area will continue to be monitored during future LTMP monitoring events as a focused slope cap inspection area.

Monitoring Interval RA-8-14 has two areas within the upper portion of this slope cap that have slag exposed on the surface. Both are located above the apparent high water line. One area is approximately 1 foot wide and 10 feet long and the other area is approximately 1 foot wide and 5 feet long. Potential response actions to address these two slope cap areas with exposed underlying materials are discussed below in Section 2.6.2.4.

No deficiencies were identified in the remaining RA 8 monitoring intervals.

- Sheen Source Removal Area: A slight milky blue sheen was observed on the surface of puddles of water at the base of this capped slope area during the Year 7, Year 10, and Year 12 inspections; however, no sheen was observed on the sediment surface. A similar sheen was noted on the water surface on other portions of the Wheeler-Osgood Waterway's northern shoreline, from west of the Sheen Source Removal Area to the mouth of the waterway during the Year 12 slope rehabilitation inspections in this area (refer to Section 5.3.2 for a summary of these observations). The source and nature of the sheen could not be determined. Two wipe samples containing this sheen were later collected from within the slope rehabilitation areas along this shoreline on August 9, 2018, for chemical analyses, with one of these wipe samples collected just west of the Sheen Source Removal Area. Neither polychlorinated biphenyls (PCBs) nor diesel- or oil-range total petroleum hydrocarbons (TPH) were detected in either of the sheen wipe samples, but both wipe samples did appear to have low-level concentrations of select polycyclic aromatic hydrocarbons (PAHs) detected. The results of these sheen wipe samples are presented in Section 5.5. No response actions are proposed for the Sheen Source Removal Area and this area will remain a focused slope cap inspection area during future LTMP monitoring events.

2.6.2.4 Proposed Response Actions

RA 3 Grout Mat

A supplemental inspection of the RA 3 grout mat was performed on October 5, 2018, to better assess the current level of damage to the grout mat and to assist in developing repair options, if needed. The inspection occurred during low-tide conditions, when predicted tides were at or lower than 0.4 feet MLLW.

The grout mat is located on a steep embankment and, for safety reasons, all previous low-tide inspections have been made visually from the floating docks located off of the toe of the slope and from the top of the slope. For the supplemental physical inspection, an environmental contractor, IO Environmental, was hired to walk out onto the grout mat slope with fall protection, perform limited marine growth removal as needed to evaluate damage, and make measurements and observations on holes and any additional damage that was observed. A representative from Floyd|Snider was onsite to direct the contractor and record measurements and observations. During a site walk with the contractor conducted prior to the supplemental physical inspection, it was discovered that the current property owner, Commencement Bay Marine Services, had made repairs to the grout mat consisting of mortar patches in some of the larger holes that had previously been noted on the grout mat surface. These repairs were made after the June 13, 2018, LTMP low-tide slope cap inspection of this grout mat and unknown to the City. For areas where mortar patches were observed during the supplemental inspection, the competency of the repair was evaluated, along with measurements of the patch size. Field observations are available in Appendix D, which includes monitoring interval diagrams and photographs from the inspection. A summary table documenting the October 2018 supplemental inspection observations and comparing the results to the June 2018 LTMP inspection observations is provided as Table 2-4.

In total, seven patched areas, seventeen separate unpatched holes, and four areas of subsidence/soft spots were observed in the grout mat during the supplemental inspection. All of the holes greater than 3 inches in diameter that were observed during the June 2018 inspection (five holes in total) were patched by Commencement Bay Marine Services (refer to Table 2-4). Additionally, Commencement Bay Marine Services patched two other locations on the mat where holes were not previously identified during the June 2018 inspection. Several patched areas are visible in photographs provided in Appendix D (Year 12_RA-13_ P1020663, Year 12_RA-13_ P1020669, and Year 12_RA-3_P1020674). One of the patches has a large vertical crack running through the middle of it that appears to be related to an adjacent crack in the surrounding grout mat (Year 12_RA-13_P1020669). The remainder of the patches made by Commencement Bay Marine Services appear to be competent and in good condition. Of the seventeen holes that were observed during the supplemental inspections, fifteen were less than 8 inches in diameter and extended less than 4 inches into the grout mat. Two larger holes were observed, one 4-inch-diameter hole with a measured depth of 9 inches, and a 4- by 20-inch hole with a measured depth of 4 inches. The subsidence/soft spots observations describe areas where the geotextile fabric on top of the mat appeared competent, but the mat buckled when weight was applied. It is unknown whether these soft spots could be attributed to voids underneath the geotextile from the time of installation, or if they are due to weathering of the grout underneath. Additional observations documented during the inspection included several areas of frayed or missing geotextile fabric on the grout mat surface and cracks in the grout in portions of the grout mat.

As documented in the Remedial Action Construction Report the grout mat slope is constructed of a 6-inch articulating block mat (ABM), overlain by a 6-inch uniform section mat (USM) placed over the existing slag debris slope in a portion of RA 3 (City of Tacoma 2003). ABM's are flexible and designed to move with the forces of differential settlement, while USM's are solid concrete linings and are typically used to reduce infiltration or exfiltration of fluids. The grout mat design was selected to provide both capping (isolation of contaminants) and maintenance of steeper slopes, which were required for continued operation of the boat haul-out facility (City of Tacoma 2003). Results of the supplemental inspection indicate that the damage appears to be limited to the overlying USM, and, as a whole, the grout mat system is currently functioning as intended. The presence of the underlying ABM layer prevents any large scale erosion from the slope, and the presence of the USM prevents fine soil/sediment from being released into the waterway. As discussed above, most of the holes observed in the USM are less than 4 inches in depth, and do not fully extend through this mat layer. One of the holes observed during the inspection was deeper than the 6-inch thickness of the USM, although it appeared to the contractor that the damage did not extend into the second layer of the grout mat. The depth of this hole may indicate that the damage in this area extends into a void space, or that the USM is thicker in this area of the grout mat.

In order to ensure that the grout mat system remains functioning as intended, the City proposes conducting an additional physical inspection of the grout mat in 2 years (2020) to assess the grout mat conditions at that time, rather than waiting until the next planned LTMP slope cap inspection, scheduled for 2023. Based on the results of the additional 2020 inspection, the City may propose to perform grout mat repair work at that time. If additional repair work is proposed, the City will submit a memorandum to EPA with the City's recommendations for repairs.

Slope Cap Areas with Exposed Underlying Material

As described in Section 2.6.2.3, there were three slope cap monitoring intervals where underlying material was observed on the upper slope surface during the Year 12 slope cap inspections. Two of these intervals are in RA 3 and one of these intervals is in RA 8.

- **Two Areas with Exposed Underlying Material in RA 3:** Exposed geotextile and a small area of the underlying sediment are present near the top of the steep slope adjacent to and south of the grout mat within Monitoring Interval RA-3-2. Additionally, there is an area of steep slope cap near the north end of Monitoring Interval RA-3-3 where concrete material and a small area of slag are exposed at the surface. Both areas are located above the apparent high water line.

- **Area with Exposed Underlying Material in RA 8:** Two locations were observed near the top of the slope within Monitoring Interval RA-8-14 where underlying slag is now exposed at the slope surface. Both of these areas are located above the apparent high water line.

It is proposed that maintenance activities be performed in these three slope cap intervals in 2019 to repair the cap surface. Any loose slag present on the slope surface will be removed and properly disposed of and the exposed slope cap surface will then be covered over with the appropriate cap materials (e.g., filter material, quarry spalls, and habitat mix). As all four exposed areas are located above the apparent high water line, this maintenance work will be conducted in the dry. A slope cap maintenance plan will be prepared and submitted to EPA for approval prior to conducting this maintenance work.

2.7 YEAR 12 REMEDIAL AREA MONITORING CONCLUSIONS AND FUTURE LONG-TERM MONITORING

Natural recovery and enhanced natural recovery monitoring was conducted in Year 12 at four natural recovery stations and one enhanced natural recovery station as part of the LTMP remedial area monitoring. Monitoring results from these natural recovery and enhanced natural recovery stations showed that either DEHP sample concentrations were less than the SQO or SQS criteria or that bioassay testing results did not exceed the SCO or CSL biological criteria. Based on these Year 12 monitoring results, natural recovery and enhanced natural recovery monitoring are no longer required during future LTMP monitoring events in accordance with the LTMP. Additionally, these outcomes for Year 12 natural recovery and enhanced natural recovery monitoring mean that all of the Thea Foss and Wheeler-Osgood Waterways RAOs have now been met and that the remedial action in these waterways can now be considered complete. Following approval of this Year 12 LTMP Monitoring Event Report by EPA, the City will schedule a pre-certification inspection with EPA and subsequently prepare a Remedial Action Report (RA Report) to document the completion of the remedial action for EPA's review and approval.

Cap physical integrity performance monitoring was conducted in Year 12 as part of the LTMP remedial area monitoring and included subtidal cap hydrographic surveys and low- tide slope cap inspections. The Year 12 subtidal cap hydrographic survey results showed that these caps have been stable over time, with most Year 12 cap surface elevations within 6 inches of the baseline or Year 2 surface elevations and within the allowable accuracy of the survey equipment. There were no proposed response actions for the subtidal cap areas. In general, the slope caps have remained intact and stable over time with most areas having no observed issues regarding cap integrity between the baseline and Year 12 low-tide slope cap monitoring events. A few exceptions have been noted in certain slope cap areas, as described in Section 2.6.2, and these areas will either be addressed through proposed response actions, as described above in Section 2.6.2.4, or will continue to be inspected as focused slope cap inspection areas during future slope cap inspections (refer to Table 2-3). Remedial area monitoring to evaluate cap physical integrity, including subtidal cap hydrographic surveys and low-tide slope cap inspections, will continue under the LTMP and will be conducted in Years 17 (2023) and 22 (2028).

3.0 Waterway Source Monitoring

Waterway source monitoring is performed to evaluate the potential for sediment recontamination within the Thea Foss and Wheeler-Osgood Waterways, including recontamination from urban and waterway operational contributions, and to help identify potential sources of recontamination within the capped, natural recovery, and dredged-to-clean areas. Additionally, waterway source surface sediment sample results will help support the City's ongoing comprehensive stormwater monitoring and source control program, as well as provide information to other regulatory agencies responsible for source control. In accordance with Section 3.0 of the LTMP, waterway source monitoring of surface sediments is conducted at twelve sample stations located throughout the waterways during LTMP monitoring event Years 12, 17, and 22. The sample station locations are shown on Figure 3-1.

This section presents a summary of the Year 12 waterway source monitoring. Following the Year 12 waterway source monitoring field work and chemical analyses, a Year 12 Waterway Source Monitoring PFM was prepared that detailed the LTMP waterway source monitoring requirements, the Year 12 waterway source monitoring field activities, the Year 12 analytical results and comparison to previous analytical results, and the preliminary findings of the Year 12 waterway source monitoring. This Waterway Source Monitoring PFM is included as Appendix E. A summary of the Waterway Source Monitoring PFM is provided in the following sections. Section 3.4 provides a summary of the Year 12 waterway source monitoring conclusions and a brief discussion of future long-term waterway source area monitoring under the LTMP.

3.1 WATERWAY SOURCE MONITORING REQUIREMENTS

The required activities for the LTMP waterway source monitoring program are discussed in this section.

Per the LTMP, waterway source monitoring would be conducted at twelve sample stations (Stations WS-1 through WS-12) located in potential source areas, such as near marinas and outfalls (refer to Figure 3-1). The waterway source surface sediment (0 to 10 cm) samples collected from these stations would be analyzed for high molecular weight polycyclic aromatic hydrocarbons (HPAHs), phthalates, metals, TOC, total solids, and grain size. Per the LTMP, these samples would be analyzed for HPAHs, phthalates, and metals, because these were the most commonly detected analytes in surface sediments throughout the waterways during previous monitoring events and because they encompass those analytes most commonly associated with potential ongoing sources including marinas, industrial operations, and stormwater discharges. The waterway source monitoring chemical analytical results would be compared to the Commencement Bay SQOs, as well as the SQS criterion for DEHP. The chemical analytical results at each waterway source monitoring sample station also would be compared with the previous OMMP monitoring analytical results collected at that station to evaluate trends over time.

More detailed waterway source monitoring requirements are provided in the Waterway Source Monitoring PFM (Appendix E) and in the Sediment Sampling Operations Manual (Appendix B of the LTMP).

3.2 SUMMARY OF YEAR 12 WATERWAY SOURCE MONITORING ACTIVITIES

The Year 12 waterway source monitoring was conducted at all twelve sample stations on June 4 and 5, 2018. Sample collection forms and photographs documenting activities and observations during the sampling event are presented in Attachment A of the Waterway Source Monitoring PFM (refer to Appendix E). Waterway source monitoring samples were designated by WS, followed by the sample station number, and then the monitoring year (e.g., WS-01-Y12). The Year 12 samples (0 to 10 cm) were discrete grabs collected using a Van Veen sampler deployed from the City's vessel. One field duplicate (sample WS-12-Y12-2), a duplicate of sample WS-12-Y12, was collected during the monitoring event.

The waterway source monitoring samples were submitted to the City laboratory under approved sample handling and chain-of-custody procedures for the analysis of HPAHs, phthalates, metals, TOC, total solids, and grain size in accordance with the LTMP.

Data validation was performed on the laboratory analyses for the waterway source monitoring samples in accordance with the LTMP. No qualifiers were added to the analytical results based on the data quality review. Data are determined to be of acceptable quality for use as reported by the laboratory. The data validation reports for these samples are included in Attachment B of the Waterway Source Monitoring PFM.

3.3 SUMMARY OF YEAR 12 WATERWAY SOURCE MONITORING FINDINGS

This section summarizes the findings of the Year 12 waterway source monitoring. The results of the Year 12 sample analyses are provided in Table 3-1. Concentrations that are greater than the SQOs are highlighted in red in Table 3-1, and the DEHP concentrations that exceed the DEHP SQO and SQS criteria are shown in Table 3-2. Additionally, Figure 3-2 presents the detected concentrations that were greater than the SQOs or the DEHP SQS in the Year 12 waterway source monitoring samples.

Also summarized in the findings below is a comparison to previous OMMP monitoring data collected at these waterway source monitoring sample stations. Refer to Tables 4 through 15 in the Waterway Source Monitoring PFM (Appendix E), which present comparisons of the Year 12 waterway source monitoring results to the previous sample results by station. For a detailed summary of the Year 12 waterway source monitoring results and comparison to previous monitoring data, refer to the Waterway Source Monitoring PFM.

The waterway source monitoring findings include the following:

- There were no SQO exceedances for metals in any of the Year 12 waterway source monitoring samples.
- Two of the Year 12 waterway source samples had no SQO or DEHP SQS exceedances. These samples were collected from Stations WS-1 and WS-3, located toward the mouth of the waterway. These results are similar to results from samples collected at these two stations during previous monitoring years, with the one exception of the Station WS-1 Year 10 sample result for DEHP that was detected just greater than the SQO.
- Two of the Year 12 waterway source samples had no SQO exceedances but did have low level DEHP SQS exceedances when the concentrations were OC-normalized. These samples were collected from Stations WS-2 and WS-4. At Station WS-2, the Year 12 OC-normalized DEHP concentration just exceeded the DEHP SQS criterion. In previous samples collected at this station, DEHP exceeded the SQO in the Year 4, Year 7, and Year 10 samples. Additionally, Year 4 and Year 7 samples from Station WS-2 had SQO exceedances of HPAHs, but these past exceedances have been attributed to sample heterogeneity at this location. At Station WS-4, the Year 12 OC-normalized DEHP concentration just exceeded the DEHP SQS criterion. Prior sample results from Station WS-4 only had DEHP exceed the SQO in Year 7.
- Samples from five waterway source sample stations (Stations WS-5, WS-6, WS-9, WS-11, and WS-12) had SQO exceedances only for DEHP in Year 12, with ratios ranging from approximately 1.1 to 1.9 times the SQO. The DEHP OC-normalized results also exceeded the DEHP SQS in samples from Stations WS-5, WS-6, WC-9, and WS-12 (only exceeded in the field duplicate sample). The OC-normalized DEHP results of the parent sample at Station WS-12 were detected just at the DEHP SQS criterion. The OC-normalized DEHP concentration for the sample from Station WS-11 was not calculated because the TOC was greater than the usual range for OC normalization.[1] DEHP sample results from previous monitoring years at these stations also generally showed DEHP SQO exceedances, with the exception of Station WS-9, where DEHP was detected at concentrations less than the DEHP SQO during the previous three monitoring events. Previous monitoring samples collected at these five stations generally had no SQO exceedances for metals, HPAHs, or other phthalates. Exceptions to this included some elevated concentrations of HPAHs in previous monitoring samples collected from Station WS-11, particularly in the Year 10 sample, and some elevated concentrations of HPAHs in the Year 10 sample from Station WS-12.

[1] The recommended range of TOC for organic carbon normalization is from 0.5 to 3.5 percent (Ecology 2017). Sediment samples with TOC outside this normal range were not calculated and the DEHP dry weight results were only compared to the SQO criterion.

- The Year 12 sample from Station WS-7 had SQO exceedances of two HPAHs, butyl benzyl phthalate, and DEHP. Station WS-7 is located in a channel sand cap area near City Outfall 230. The detections of both benzo(g,h,i)perylene and indeno(1,2,3-c,d)pyrene in the Year 12 sample were at or less than 1.3 times their respective SQOs. These HPAHs have also been frequently detected in previous monitoring samples collected from this station at similar concentrations. The SQO exceedances of butyl benzyl phthalate and DEHP in the Year 12 sample were detected at approximately 1.2 and 5.8 times their SQOs, respectively. Butyl benzyl phthalate concentrations did not exceed the SQO in any of the previous samples from this station; however, DEHP exceeded the SQO in all previous samples from this station since Year 2. The DEHP SQO exceedance in the Year 12 sample is the greatest exceedance reported to date at this station. The OC-normalized DEHP concentration for this sample was not calculated because the TOC was greater than the usual range for OC normalization.

- Four HPAHs and DEHP exceeded their SQOs in the Year 12 sample collected from Station WS-8. This station is located in a natural recovery area in a marina on the eastern side of the central portion of the Thea Foss Waterway. The HPAH SQO exceedances were at or less than approximately 1.3 times their respective SQOs, and DEHP was detected at approximately 1.8 times its SQO in the Year 12 sample. The OC-normalized DEHP concentration for this sample was not calculated because the TOC was greater than the usual range for OC normalization. Several HPAHs and DEHP were also detected at concentrations greater than their SQOs in the previous monitoring samples collected from this station, with the exception of the Year 10 sample that had no HPAH or phthalate SQO exceedances.

- The Year 12 sample from Station WS-10 had SQO exceedances of two HPAHs and DEHP. This station is located in a channel sand cap area located on the eastern side of the southern portion of the Thea Foss Waterway and in the vicinity of a marina and City Outfall 245. The Year 12 HPAH concentrations for benzo(g,h,i)perylene and indeno(1,2,3-c,d)pyrene were just greater than their respective SQOs, detected at or less than approximately 1.2 times their SQOs. DEHP in the Year 12 sample was detected at 3.3 times the SQO. In samples from previous monitoring years, there have been no exceedances of HPAHs; however, DEHP exceeded its SQO in the Year 7 and Year 10 samples. The DEHP SQO exceedance in the Year 12 sample is the greatest exceedance reported to date at this station. The OC-normalized DEHP concentration for this sample was not calculated because the TOC was greater than the usual range for OC normalization.

3.4 YEAR 12 WATERWAY SOURCE MONITORING CONCLUSIONS AND FUTURE LONG-TERM MONITORING

Based on the results of the Year 12 waterway source monitoring, no response actions are proposed at this time. No metals exceeded the SQOs at the twelve waterway source monitoring stations, and HPAHs were detected just exceeding their SQOs at three of these stations. There were DEHP SQO and/or SQS exceedances at 10 of the 12 waterway source monitoring stations, but these results were generally consistent with the DEHP results from the past OMMP monitoring samples collected at these stations. At Stations WS-7 and WS-10, the Year 12 DEHP concentrations were greater in comparison to previous DEHP concentrations at these stations; however, concentrations have generally been variable over time. DEHP is a known ongoing urban and waterway operational contaminant and will continue to be monitored at these stations during future LTMP monitoring events.

Waterway source monitoring will continue to occur at the 12 monitoring stations during future LTMP monitoring events, occurring in Year 17 (2023) and 22 (2028).

4.0 Confined Disposal Facility Monitoring

The fourth performance monitoring event for the St. Paul CDF was conducted in Year 12 (2018). This performance monitoring event included surface water and groundwater sampling and analysis, as well as CDF berm and cap inspections, and was performed in accordance with the CDF monitoring requirements specified in the LTMP.

Under the OMMP, baseline monitoring and performance monitoring of the groundwater quality at the CDF were completed for 10 years after completion of the remedial action to characterize post-construction groundwater quality and flow conditions to ensure the protection of adjacent surface water. The baseline monitoring consisted of 8 quarterly monitoring events and was completed in 2008, 2 years following construction of the CDF, and was used to assess the groundwater baseline conditions, as summarized in the Baseline Water Quality Conditions Report (City of Tacoma 2009b). Subsequent to the baseline monitoring, CDF performance monitoring was performed in Year 4 (2010), Year 7 (2013), and Year 10 (2016), in accordance with the CDF Performance Monitoring Plan (City of Tacoma 2009a) and the OMMP. Similar to the Year 12 CDF performance monitoring, these previous performance monitoring events also included surface water and groundwater sampling and analysis and CDF berm and cap inspections. The results from the previous performance monitoring events were used to prepare a plan for long-term monitoring of the CDF, as described in the LTMP and in the Confined Disposal Facility Monitoring Operations Manual (Appendix D of the LTMP).

The objective of performance monitoring under the LTMP is to compare long-term post-construction groundwater quality to baseline conditions, in order to determine if constituents are being transported in groundwater from the CDF at concentrations that could pose a potential threat to surface water quality at the point of compliance. The point of compliance for CDF monitoring is the sediment/surface water interface outside of the berm and peninsula surrounding the CDF. The performance standard for the monitoring program is to evaluate if statistically significant increases in contaminant concentrations relative to the established baseline concentrations are observed. An ambient surface water quality sample is also collected to establish background conditions in the adjacent surface water, and visual observations of the St. Paul CDF containment and offset berms and surface of the CDF cap (where visible) are made to document the condition of the berms and the cap as part of the LTMP performance monitoring.

This section presents a summary of the Year 12 CDF performance monitoring requirements, activities, and findings. The detailed results of the Year 12 performance monitoring event are documented in the St. Paul Waterway Confined Disposal Facility Year 12 (2018) Performance Monitoring Memorandum (CDF Performance Monitoring Memorandum), included as Appendix F. Section 4.4 provides a summary of the Year 12 CDF performance monitoring conclusions and a brief discussion of future long-term CDF performance monitoring under the LTMP.

4.1 CDF PERFORMANCE MONITORING REQUIREMENTS

The CDF long-term monitoring program requirements are summarized in this section. Additional details, including groundwater and surface water sampling and analysis and quality assurance (QA) protocols, are presented in the Confined Disposal Facility Monitoring Operations Manual (Appendix D of the LTMP). All LTMP monitoring activities, including groundwater and surface water sampling activities, are conducted using similar procedures as those used during baseline and performance monitoring (Years 1 through 10) to provide consistency between collection and analyses of data as well as statistical evaluations.

The monitoring program was designed to evaluate groundwater quality in areas surrounding the CDF to ensure continued compliance with the performance criteria. Per the LTMP, groundwater samples would be collected from four shallow monitoring wells (MW-01, MW-02, MW-06, and MW-10) and two deep monitoring wells (MW-08 and MW-12; refer to Figure 4-1). During the CDF monitoring, groundwater levels would be measured in these wells to aid in the determination of groundwater flow directions and magnitudes at the time of monitoring. As set forth in the LTMP, groundwater samples would not be collected within 2 hours on either side of the monitoring day's high tide, as the groundwater sample results may be overly influenced by saltwater intrusion. Low-flow sampling techniques would be used for well purging and sample collection. Field parameters, including temperature, pH, electrical conductivity, dissolved oxygen and turbidity, would be measured and recorded prior to sample collection using a multi-parameter field meter.

An ambient surface water sample would be collected at one monitoring location, SWM-01, adjacent to the end of the St. Paul/Middle Waterway Peninsula near the mouths of the St. Paul and Middle Waterways and the Puyallup River (Figure 4-1). This surface water sample would be collected during high slack tide from approximately 3 feet below the water surface.

The groundwater and surface water samples would be analyzed for total mercury, dissolved metals, PAHs, TOC, salinity, and total suspended solids (TSS). The analytical results from the groundwater samples would be statistically compared to each analyte's distribution observed during the 2-year baseline monitoring program. If statistically significant increases in groundwater concentrations are observed, the City must notify EPA and propose to EPA whether to initiate one or more response actions appropriate to the nature of the increase, as described in the LTMP.

Monitoring of the CDF containment and offset berms and the CDF would be conducted by visual inspection. These areas of the CDF are shown on Figure 4-2. The inspections would document any changes in the berm structures, integrity of the cap, and any evidence of release or contamination using field forms and representative photographs. The condition of the CDF stormwater swale and offset berms also would be noted on the CDF cap inspection form. Changes in cap conditions associated with development also would be documented on the inspection form.

4.2 SUMMARY OF YEAR 12 CDF PERFORMANCE MONITORING ACTIVITIES

The Year 12 CDF performance monitoring was completed in three parts. Well redevelopment was completed between May 23 and 25, 2018, groundwater and surface water monitoring was completed on June 18 and 19, 2018, and CDF visual inspection was conducted on July 26, 2018.

To improve the productivity of the performance monitoring wells ahead of the performance monitoring sampling event, the six monitoring wells were redeveloped on May 23 and 25, 2018.

A surface water sample, plus a field duplicate sample, were collected from the City's vessel at the surface water monitoring location, SWM-01, during high tide on June 19, 2018. The surface water sample location is shown on Figure 4-1. Water quality field parameters were measured during surface water collection using a Horiba U-50 series multiprobe system. Conductivity was measured in the field. The surface water samples were submitted under chain of custody to the City laboratory on June 19, 2018, for the analysis of salinity, total mercury, and dissolved metals (copper, lead, nickel, zinc, and mercury).

Groundwater samples were collected from the six performance monitoring wells (MW-01, MW-02, MW-06, MW-10, MW-08, MW-12) on June 18 and 19, 2018. The monitoring well locations are shown on Figure 4-1. Groundwater sampling was performed in general accordance with the procedures specified in the Confined Disposal Facility Monitoring Operations Manual (Appendix D of the LTMP). Grundfos pumps were used for wells MW-01, MW-08, MW-10, and MW-12, and a peristaltic pump was used for wells MW-02 and MW-06. Groundwater sampling included collection of a rinsate blank sample. All compounds analyzed in the rinsate blank were detected at concentrations less than laboratory reporting limits, which indicates that decontamination procedures were effective.

The groundwater elevation was measured at each monitoring well prior to sampling. Water quality field parameters were measured during groundwater sample collection using a Horiba U-50 series multiprobe system. Conductivity was measured in the field. Groundwater samples were collected using low-flow sampling techniques, with purging and sampling flow rates ranging from approximately 0.1 liters/minute to 0.45 liters/minute. Each performance monitoring well was purged for a minimum of 50 minutes, and the volume purged in the performance monitoring wells ranged from approximately 5.5 liters (1.5 gallons) to approximately 54.5 liters (14.4 gallons).

Groundwater samples were submitted under chain of custody to the City laboratory on June 18 and 19, 2018, for the analysis of total mercury, dissolved metals (copper, lead, nickel, zinc, and mercury), PAHs, salinity, TOC, and TSS.

A data quality review was performed on the laboratory analyses for the surface water and groundwater samples in accordance with the LTMP. Several groundwater samples for which lead and copper were non-detect were qualified (UJ) for being estimated values less than the reporting limit. Data quality was found to be acceptable and the data are acceptable for use as qualified. The data quality review reports for these samples are included in Attachment D of the CDF Performance Monitoring Memorandum (Appendix F).

Inspection of the containment berm was performed on July 26, 2018. However, inspections of the offset berm and CDF cap have not yet been completed due to active construction occurring in this area. Representative photographs related to the July 26, 2018, containment berm inspection and the construction work occurring on the CDF cap are included as Attachment C in the CDF Performance Monitoring Memorandum.

4.3 SUMMARY OF YEAR 12 CDF PERFORMANCE MONITORING FINDINGS

The findings from the Year 12 CDF performance monitoring are summarized in this section. Table 4-1 summarizes the Year 12 surface water analytical results at monitoring location SWM-01. Tables 4-2 and 4-3 provide tabulated summaries of the analytical results for the Year 12 CDF performance monitoring shallow and deep groundwater samples, respectively, and a comparison of these results to the baseline mean and baseline 95th percentile Upper Tolerance Level (UTL) criteria. For a detailed summary of the Year 12 CDF performance monitoring results and comparison to performance criteria, refer to the CDF Performance Monitoring Memorandum.

Surface Water Monitoring

- Copper, lead, nickel, mercury, and zinc were not detected in either the ambient surface water sample or the field duplicate.

Groundwater Monitoring

- During the Year 12 performance monitoring, TOC was detected at concentrations exceeding the baseline 95th percentile UTL performance criteria in wells MW-08 and MW-10. Dissolved oxygen was measured at a concentration exceeding the baseline 95th percentile UTL performance criteria in deep well MW-12, which is likely attributable to field measurement variability.
- pH readings for all monitoring wells were notably lower in most wells (MW-02, MW-06, MW-08, MW-10, and MW-12) than measured during Year 4, Year 7, and Year 10 performance monitoring; however, these lower measurements are likely attributable to an error with the probe.
- Conductivity readings in wells MW-02 and MW-10 were less than Year 4, Year 7, and Year 10 performance monitoring results. These readings may indicate a greater fraction from fresh water recharge than in previous monitoring events.

- The temperature for MW-08 was recorded as 30.3 degrees Celsius, which is unusually high and may be attributed to the sample being collected during the hottest time of a very warm day. Temperatures for other wells recorded typical readings.
- Dissolved lead, dissolved mercury, and total mercury were not detected in any groundwater samples collected from the performance monitoring wells.
- Dissolved nickel was detected in all performance monitoring wells except for MW-10, and dissolved zinc was detected in all performance monitoring wells.
- Dissolved copper was detected in two performance monitoring wells: MW-01 and MW-06.
- Consistent with baseline monitoring, the greatest concentrations of dissolved copper and dissolved zinc were detected in MW-06. Year 12 concentrations were less than the baseline 95th percentile UTL performance criteria for both of these metals at MW-06.
- MW-06 is an outlier for metals indicating that detections are likely associated with a localized source and not groundwater transport from the CDF.
- The greatest concentration of dissolved nickel was detected in MW-08, which is the first time it was been detected since baseline monitoring. However, this dissolved nickel concentration was less the baseline 95th percentile UTL performance criteria for MW-08.
- All detected metal concentrations are within the range of those observed during baseline monitoring and less than their respective baseline 95th percentile UTL.
- PAHs were not detected in performance monitoring wells MW-01 and MW-06.
- Only one PAH was detected in MW-02 during the Year 12 performance monitoring, which is fewer than in previous performance monitoring events. Five PAHs were detected in MW-02 as part of Year 10 performance monitoring.
- 2-methlynaphthalene was detected in deep wells MW-08 and MW-12 for the first time at low level concentrations that were close to the reporting limits.
- Naphthalene was detected in deep well MW-08 for the first time since baseline monitoring, and in deep well MW-12 for the first time since the Year 4 performance monitoring.
- Seven PAHs were detected in MW-10 during the Year 12 performance monitoring. These results are anomalous compared to previous monitoring. Four of the seven PAHs were never detected during baseline monitoring or Year 4, Year 7, or Year 10 performance monitoring events. Subsequent to baseline monitoring, no PAHs were detected at MW-10 except fluoranthene during the Year 4 monitoring. Future performance monitoring results will be evaluated for trends in PAH concentrations at MW-10.

- All detected PAH concentrations are within the range of those concentrations observed during baseline monitoring, except naphthalene at MW-08, MW-10, and MW-12.
- There were no PAH exceedances of baseline 95th percentile UTL performance criteria during this performance monitoring event where these comparisons could be made.

CDF Berm and Cap Inspections

- Cap and offset berm inspections have not yet been completed due to ongoing construction activities on the CDF cap.
- No sheens or other indications of contamination were identified during inspection of the containment berm.
- Consistent with previous monitoring events, seeps were observed toward the eastern end of the containment berm on the lower beach. There was no indication of contamination in these seeps.
- Some riprap remains exposed on the outward face of the containment berm at the upper slope of the beach. The area appears generally consistent and stable relative to previous observations. The containment berm does not appear to be compromised.
- Inspection of the offset berm and CDF cap will be performed when construction in this area is complete.

4.4 YEAR 12 CDF PERFORMANCE MONITORING CONCLUSIONS AND FUTURE LONG-TERM MONITORING

Data of acceptable quality were collected from all performance monitoring wells and the adjacent surface water location during the Year 12 performance monitoring event to achieve the objectives of CDF performance monitoring. Analyte concentrations detected in wells during performance monitoring were compared to the baseline mean and baseline 95th percentile UTL performance criteria. This allowed for the evaluation of the effectiveness and protectiveness of the CDF remedy during Year 12 performance monitoring. There were no PAH or metal exceedances of the baseline 95th percentile UTL performance criteria.

The results of baseline monitoring indicated that the metal concentrations detected in MW-06 are likely associated with a localized source, as dissolved copper and dissolved zinc were not detected or were detected at significantly lower concentrations in other shallow groundwater wells (MW-01, MW-02, and MW-10). The Year 12 performance monitoring results indicate that the elevated zinc and copper concentrations detected in MW-06 remain localized and are not associated with statistically significant increases in chemical concentrations in groundwater flowing from the CDF. Consistent with baseline monitoring, elevated zinc and copper concentrations were not detected in other shallow performance monitoring wells, or in previous monitoring events of upgradient CDF well MW-04 (no longer an active well).

In shallow performance monitoring well MW-02, only one PAH, anthracene, was detected in Year 12 at low level concentrations that were close to the reporting limits and within the range of concentrations detected during baseline monitoring and the Year 4, Year 7, and Year 10 performance monitoring events. This is a reduction of the number of detected PAHs when compared to previous performance monitoring events.

In shallow performance monitoring well MW-10, seven PAHs were detected in Year 12 monitoring. These anomalous results will be evaluated with future performance monitoring results to assess trends in PAH concentrations at MW-10. Additionally, in deep wells MW-08 and MW-12, 2-methlynaphthalene was detected for the first time, at relatively low level concentrations, and naphthalene was detected in MW-08 for the first time since baseline monitoring, and in MW-12 for the first time since Year 4 performance monitoring.

This comparison of long-term post-construction groundwater quality to the established baseline conditions indicates that no constituents are being transported in groundwater from the CDF at concentrations that are expected to pose a potential threat to surface water quality at the point of compliance. No statistically significant increases in contaminant concentrations relative to the established groundwater baseline 95th percentile criteria have been observed, where these comparisons can be made. This evaluation indicates that baseline concentrations are not exceeded in the surface water outside of the CDF, confirming the continued effectiveness and protectiveness of the remedy. Based on the results of the Year 12 findings, no response actions are proposed at this time.

Groundwater and surface water performance monitoring and evaluation of groundwater quality and protectiveness of surface water will be conducted again during future LTMP monitoring events, occurring in Year 17 (2023) and Year 22 (2028).

5.0 Habitat Mitigation/Restoration Area Monitoring

Habitat mitigation/restoration area monitoring is performed to ensure the ongoing success of the habitat mitigation/restoration areas constructed as part of the Thea Foss and Wheeler-Osgood Waterways Remediation Project, and to confirm that these areas continue to provide their desired function and objectives as intertidal habitat. As mitigation for effects of the remediation project on aquatic habitat, the City constructed four habitat sites in the Commencement Bay area (refer to Figure 1-1): two in the Middle Waterway (North Beach Habitat and Middle Waterway Tideflat Habitat), one in the intertidal reach of the Puyallup River main stem (Puyallup River Side Channel), and one in the intertidal reach of Hylebos Creek (Hylebos Creek Mitigation Site). In addition, the City constructed four habitat enhancement areas within the Thea Foss Waterway (Johnny's Dock Habitat Enhancement, Head of Thea Foss Shoreline Habitat, SR 509 Esplanade Riparian Habitat, and the Log Step Habitat Enhancement). As part of the remedial action, the City also performed slope rehabilitation activities along most of the shoreline in the Wheeler-Osgood Waterway, in RAs 10, 11, and 13, and in one shoreline area in the Thea Foss Waterway, in RA 15, to provide more suitable habitat in these intertidal areas. The locations of the slope rehabilitation areas, as well as the habitat enhancement areas, within the Thea Foss and Wheeler-Osgood Waterways are shown in Figure 5-1.

This section presents a summary of the Year 12 habitat mitigation/restoration area monitoring activities. Following the Year 12 habitat mitigation/restoration area monitoring field work, a Year 12 Habitat Mitigation and Slope Rehabilitation Area PFM (Habitat PFM) was prepared that detailed the LTMP monitoring requirements for the habitat mitigation, habitat enhancement, and slope rehabilitation areas, the Year 12 field activities, and the preliminary findings of the Year 12 LTMP monitoring performed in the habitat mitigation, habitat enhancement, and slope rehabilitation areas. This Habitat PFM is included as Appendix G. A summary of the Habitat PFM is provided in the following sections. Section 5.6 provides a summary of the Year 12 habitat mitigation/restoration area monitoring conclusions and a brief discussion of future long-term habitat mitigation/restoration area monitoring under the LTMP.

5.1 HABITAT MITIGATION/RESTORATION AREA MONITORING REQUIREMENTS

The required activities for the LTMP habitat mitigation/restoration area monitoring program are discussed in this section.

5.1.1 Habitat Mitigation and Enhancement Areas

Per the LTMP, in the habitat mitigation and enhancement areas, a combination of qualitative ground surveys and representative photographic documentation would be conducted to ensure that these areas continue to mature and provide their desired function and objectives for each area over time. These site evaluations would be performed at the habitat mitigation and enhancement areas in July during each monitoring year. The general locations of the habitat mitigation and enhancement areas are shown in Figures 1-1 and 5-1, while more detailed information about each of the four mitigation areas are included in Figures 5-2 through 5-5. Representative photographs would be taken in each habitat mitigation and enhancement area during these site evaluations when tidal elevations are approximately 0 feet MLLW or lower. Field notes and photographs would be used to document observations at the habitat mitigation and enhancement areas during the site evaluations.

More detailed habitat mitigation and enhancement area site evaluation requirements are provided in the Habitat PFM and in the Habitat Mitigation/Restoration Area Monitoring Operations Manual in the LTMP.

5.1.2 Slope Rehabilitation Areas

Per the LTMP, in the slope rehabilitation areas, visual shoreline inspections would be conducted as to ensure that these intertidal areas continue to provide suitable intertidal habitat. These visual inspections would be performed in the slope rehabilitation areas present in RAs 10, 11, 13, and 15 during periods of low tide (when predicted tidal elevations are 0 feet MLLW or lower). The locations of these slope rehabilitation areas are shown on Figure 5-1. Field notes and photographs would be used to document observations of the slope rehabilitation areas during the visual inspections.

More detailed low-tide slope cap inspections requirements are provided in the Habitat PFM and in the Habitat Mitigation/Restoration Area Monitoring Operations Manual in the LTMP.

5.2 SUMMARY OF YEAR 12 HABITAT MITIGATION/RESTORATION AREA INSPECTION ACTIVITIES

5.2.1 Habitat Mitigation and Enhancement Areas

Year 12 habitat mitigation and enhancement area site evaluations and representative photo documentation were performed between July 25 and July 27, 2018. The habitat mitigation and enhancement areas are shown on Figures 5-1 through 5-5. The site evaluations were performed in each area during periods of lower tides, and the representative photographs at each area were taken when actual tidal elevations were below 0 feet MLLW, except at the Hylebos Creek Mitigation Site where photographs were taken when tidal elevations were less than 8.8 feet MLLW, as allowed in the LTMP.

The field forms and photographs that were used to document observations of the habitat mitigation and enhancement areas during the Year 12 qualitative site evaluations are provided as Attachment A in the Habitat PFM (refer to Appendix G).

5.2.2 Slope Rehabilitation Areas

Year 12 slope rehabilitation inspections were performed in RA 15 on June 27, 2018, and in RAs 10, 11, and 13 on June 28, 2018. The inspection areas and the inspection starting and end points are shown on Figure 5-1. The visual inspections within the slope rehabilitation areas were performed when actual tidal elevations were at or below 0.0 feet MLLW. Photographs were taken approximately every 50 feet within each of the slope rehabilitation areas to document the slope conditions. Photographs were also taken to document notable observations, where applicable.

The field forms and photographs that were used to document observations of the slope rehabilitation areas during the Year 12 visual inspections are provided as Attachment B in the Habitat PFM (refer to Appendix G).

5.3 SUMMARY OF YEAR 12 HABITAT MITIGATION/RESTORATION AREA INSPECTION FINDINGS

5.3.1 Habitat Mitigation and Enhancement Areas

A detailed summary of the Year 12 site evaluations for each of the habitat mitigation and enhancement areas is provided in the Habitat PFM (Appendix G). This section presents a brief summary of the findings from the Year 12 site evaluations.

In all, most of the habitat mitigation and enhancement areas were found to be in excellent condition. The North Beach Habitat was noted as being in fair condition with active construction occurring adjacent to this habitat area which limited the ability for the City to water during the very dry summer. The SR 509 Esplanade Riparian Habitat was noted to be in fair to good condition primarily due to human impacts in this area, which is located adjacent to a public park.

Very few follow-up actions were identified during the Year 12 site evaluations. The follow-up maintenance activities that were identified are discussed in more detail in the Habitat PFM and are summarized in Table 5-1. In general, the follow-up maintenance activities include minor invasive removal and trash removal at all of the habitat mitigation and enhancement area, with more significant coordination of cleanup from encampment activity required at the Puyallup River Side Channel and the Middle Waterway Tideflat Habitat. All large woody debris needs to have the anchors checked and tightened periodically. At the four mitigation sites, any remaining stakes and irrigation system components can be removed. Finally, supplemental plantings will be done at the Puyallup River Side Channel in a continued effort to eliminate social trails and prevent transient activity, as well as at the Hylebos Creek Mitigation site to help shade out the reed canary grass.

5.3.2 Slope Rehabilitation Areas

Year 12 is the first year that visual inspections have been performed within the slope rehabilitation areas located in RAs 10, 11, 13, and 15. A detailed summary of the Year 12 visual inspections for each of the slope rehabilitation areas is provided in the Habitat PFM (Appendix G). This section presents a brief summary of the findings from the Year 12 slope rehabilitation inspections.

No concerns were identified upon inspection of the slope rehabilitation areas within RA 11 and RA 15 in Year 12. The RA 11 slope rehabilitation area covers a portion of the southern shoreline in the Wheeler-Osgood Waterway and the RA 15 slope rehabilitation area is located on the eastern side of the Thea Foss Waterway (refer to Figure 5-1).

During the Year 12 slope rehabilitation inspections on the northern shoreline in the Wheeler-Osgood Waterway, including a portion of the RA 13 slope rehabilitation area and all of the RA 10 slope rehabilitation area, a slight milky blue sheen was observed on the water's surface in the lower portion of the slopes in areas, generally in locations where water was observed accumulating on the slope surface. One of the largest areas where this sheen was observed during the Year 12 inspections was within RA 13, located at the base of the slope adjacent to and west of the slope cap area referred to as the Sheen Source Removal Area. The location of the Sheen Source Removal Area is shown on Figure 5-1 and further discussion of this slope cap area is provided in Section 2.6.2. A similar sheen was observed within the Sheen Source Removal Area, at the base of the slope on the water's surface, during previous inspections performed in this slope cap area in Years 7 and 10. The other areas with sheen observed along the northern shoreline of RA 13 during the Year 12 inspection tended to be smaller, isolated spots. Within RA 10, there were three notable areas along the shoreline where scattered sheen spots were visible during the Year 12 inspection. The source of the sheen could not be determined but may be biological in nature. There was no odor associated with this sheen. At the request of EPA, two samples containing this observed sheen were collected from the Wheeler-Osgood Waterway's northern slope during low-tide conditions on August 9, 2018, one within RA 10 and one within RA 13, and were submitted for analysis of PCBs, TPH, PAHs, and TOC. A summary of this sheen sampling and the analytical results are provided in Section 5.5. No other concerns were identified during the Year 12 inspections of the RA 10 and RA 13 slope rehabilitation areas.

5.4 HABITAT MITIGATION AND ENHANCEMENT AREAS MAINTENANCE ACTIVITIES

Routine maintenance is performed on an ongoing basis throughout the year in the habitat mitigation and enhancement areas, and is a key component of the City's habitat maintenance and monitoring program. The City maintains a contract with the Washington Conservation Corps (WCC) to provide a crew for performance of these routine maintenance activities in the various mitigation and enhancement areas. The crew picks up garbage, waters vegetation, tightens large woody debris cables, pulls or cuts weeds, and replants on an as needed basis. In addition, the City currently contracts with NRC Environmental Services Inc. as needed to clean up homeless encampments in the habitat areas when they are discovered. "No Trespassing" signs have been posted with the intent of discouraging settlement in these sensitive locations.

A summary of WCC's work performed during each quarter of the past year has been provided to EPA in the quarterly progress reports. As indicated in Section 5.3.1, very few maintenance activities were identified in the mitigation and enhancement areas during the Year 12 site evaluations. Work performed by the WCC since these site evaluations primarily has included invasive and trash removal in all of the areas and spot spraying the blackberry at the Log Step

Habitat Enhancement, which occurred in August. Remaining maintenance activities identified in Table 5-1 are planned for fall 2018, and updates will be provided to EPA in the quarterly progress reports.

5.5 EVALUATION OF SHEEN IN SELECT SLOPE REHABILITATION AREAS

As summarized in Section 5.3.2, during the Year 12 slope rehabilitation inspections, a slight milky blue sheen was observed on the water's surface in the lower portion of the slope in some of the slope rehabilitation areas located on the northern shoreline of the Wheeler Osgood Waterway. The eastern end of this northern shoreline is part of the RA 13 slope rehabilitation area, while the western end of this northern shoreline is the RA 10 slope rehabilitation area (refer to Figure 5-1). At the request of EPA, two samples containing this observed sheen were collected from the waterway's northern slope during low-tide conditions and submitted for chemical analysis. The sheen sampling activities and analytical results are described below.

5.5.1 Summary of Sheen Sampling Activities

Two sheen samples were collected from the slope rehabilitation areas on the Wheeler-Osgood Waterway's northern shoreline on August 9, 2018, during low-tide conditions (predicted tides were lower than -1.0 feet MLLW at the time of sampling). One sample was collected in RA 10, sample RA10 Sheen-Y12, and one sample was collected in RA 13, sample RA13 Sheen-Y12. The sheen samples were collected in the shoreline areas where the sheen was observed to be the most predominant in these RAs on the day the sampling occurred. The two sheen sample locations are shown on Figure 5-6. Field notes and selected photographs documenting the sheen sampling and observations are provided in Appendix H.

On the day the sampling occurred, sheen sampling was first attempted within RA 13 beginning around 9:00 am. However, at that time only two small patches of the milky blue sheen (each approximately 2 inch by 2 inches in extent) were observed along the northern shoreline in RA 13 and no sheen was observed in the portion of RA 13 where the sheen was observed to be most prevalent during the Year 12 visual inspection, located adjacent to and west of the Sheen Source Removal Area (refer to the photograph labeled Year 12_RA-13_P1020547 taken at 9:18 am in Appendix H). As not enough sheen was present to sample in RA 13, a search for sheen to sample in RA 10 began at 9:30 am. Again, it was difficult to find the milky blue sheen along the RA 10 shoreline, until the western end of the RA 10 shoreline was reached. Near the western end of RA 10, the milky blue sheen was observed to be faint and difficult to see on the water ponded on the slope surface, but it appeared to present in spots over an area covering approximately 15 feet by 20 feet. A close-up photograph of the sheen in this area of RA 10 is included in Appendix H (Year 12_RA-10_P1020571). The location of this sheen was one of the main areas of sheen identified within RA 10 during the Year 12 slope rehabilitation inspection.

A sample of the sheen, sample RA10 Sheen-Y12, was collected in the RA 10 sheen area using cotton gauze wipes, as not enough water with visible sheen was present on the surface of the sediments to attempt to collect a sample using a peristaltic pump. A total of five wipes (2 inches by 2 inches each) were used to collect this sheen sample. Each of the wipes was placed on the sheen in this area with tweezers, and then the wipe was flipped over on another area of sheen to capture additional sheen on the wipe. Each wipe was then placed in its own small glass jar with the tweezers. Due to the limited amount of water present on the surface of the sediment, it was difficult to collect a wipe sample without also collecting some sediment on the surface of the wipe. A sequence of photographs showing how the sheen sampling in RA 10 was conducted is included in Appendix H.

After collecting sample RA10 Sheen-Y12, another search for the milky blue sheen in RA 13 was conducted. Walking back along the RA 10 shoreline on the way to the RA 13 shoreline, additional sheen was observed in RA 10 in areas of the shoreline where it was not previously observed during the first pass through this area earlier in the day, indicating that more sheen was beginning to appear on the shoreline as the day progressed. Additionally, a larger area containing a faint milky blue sheen was also observed to be present in RA 13, located adjacent to and west of the Sheen Source Removal Area, by 10:45 am. As noted above, this was the same area that was visually inspected 1.5 hours earlier in the day and no sheen was observed. Photographs comparing this area of RA 13 at 9:18 am and 10:48 am are provided in Appendix H (Year 12_RA-13_ P1020547 and Year 12_RA-13_ P1020589). A sample of sheen, sample RA13 Sheen-Y12, was collected in this area of RA 13 using five cotton gauze wipes and following the same procedures described above.

5.5.2 Summary of Analytical Results

The two sheen wipe samples were submitted to the City laboratory under approved sampling handling and chain-of-custody procedures for the analysis of PCBs, diesel- and oil-range TPH, PAHs, and TOC. Data validation was performed on the laboratory analyses for the sheen wipe samples. Four PAHs were detected in the blank sample and the non-detects for these analytes in samples were qualified as estimated (UJ) as a result, with the exception of fluorene in sample RA 10 Sheen-Y12. Data are determined to be of acceptable quality for use as reported by the laboratory. The analytical and data validation report for these samples is included in Appendix I.

The sheen wipe sample analytical results are provided in either milligrams per wipe (mg/wipe) or micrograms per wipe (µg/wipe) and are presented in Table 5-2. There are no criteria to compare these samples with, rather these results are used to indicate whether or not the analytes are present in the sheen samples collected.

No PCBs, diesel- or oil-range TPH, or low molecular weight polycyclic aromatic hydrocarbons (LPAHs) were detected in either of the samples. All of the HPAHs, with the exception of dibenz(a,h)anthracene, were detected in both samples. However, the HPAH concentrations reported in both of these samples were just greater than the practical quantitation limits (PQLs) for these HPAHs. The PQLs for these HPAHs were reported at 0.01 µg/wipe (or 0.02 µg/wipe for benzo(b,k)fluoranthene; refer to Appendix I). HPAHs do not appear to be major component of the sheen.

Additionally, as part of the Year 12 LTMP monitoring activities, two waterway source monitoring sediment samples (WS-4 and WS-5) were collected within the Wheeler-Osgood Waterway adjacent to the two slope rehabilitation areas containing this sheen (refer to Figure 3-1). These two sediment samples were also analyzed for HPAHs and the concentrations of the HPAHs present in these sediment samples were all much less than their respective SQOs (refer to Table 3-1), indicating that HPAHs are not of concern in this area.

5.6 YEAR 12 HABITAT MITIGATION/RESTORATION AREA MONITORING CONCLUSIONS AND FUTURE LONG-TERM MONITORING

Overall, the habitat mitigation and enhancement areas appear mature and are continuing to provide their desired function and objectives as intertidal habitat areas. Only minor follow-up maintenance activities were identified during the Year 12 monitoring. The habitat mitigation and enhancement areas will continue to be maintained on a routine basis by the WCC crew with updates provided by the City in quarterly monitoring reports submitted to EPA. Qualitative monitoring of these sites and evaluation of their continued function will be conducted during future LTMP monitoring events, occurring in Year 17 (2023) and 22 (2028).

During the Year 12 slope rehabilitation monitoring, the only concern identified was the milky blue sheen present on the shoreline in RA 10 and portion of the shoreline in RA 13. Chemical analysis of two sheen samples collected in these RAs indicate that PCBs, diesel- or oil-range TPH, and PAHs are either not present in the sheen or are only present in trace amounts. No other response actions are proposed for the sheen present in RA 10 and RA 13. The slope rehabilitation areas in RAs 10, 11, 13, and 15 will continue to be inspected during future LTMP slope rehabilitation inspections, occurring in Year 17 (2023) and 22 (2028).

6.0 References

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Thea Foss and Wheeler-Osgood Waterways
Remediation Project

Year 12 LTMP Monitoring Event Report

Tables

Table 1-1
Summary of Completed Remedial Actions, Descriptions, and Remedial Areas

Action	Action Description	Remedial Areas (RA)
Natural Recovery	Areas that are not designated for active remedial action because the area was expected to recover naturally (i.e., surface sediment concentrations to meet the Sediment Quality Objectives [SQOs]) within 10 years of completion of sediment remedial action.	RA NR-1, RA NR-2, RA NR-3, RA NR-4, and northern portions of RA 5, RA 6, and RA 7
Enhanced Natural Recovery	Placement of a thin layer (i.e., 6 inches) of clean material (i.e., channel sand cap material) to facilitate natural recovery in the 10 years following completion of the remedial action.	RA 7
Dredged to Clean	Removal of sediment with contaminant concentrations greater than the SQOs at the final dredge surface.	RA 5, RA 6, RA 15, RA 16, and RA 17
Dredged and Backfilled1	Placement of channel sand cap material to meet the surrounding grade (i.e., surrounding sediment surface elevation) in an area where dredging has removed sediment with contaminant concentrations greater than the SQOs.	RA 2, RA 4, and RA 12
Channel Sand Cap	Placement of a minimum of 3 feet of channel sand cap material composed of imported sand (i.e., 100 percent passing the 3/8-inch sieve size, 85 to 100 percent passing the No. 4 sieve size, and 25 to 45 percent passing the No. 10 sieve size) from an upland quarry to confine underlying sediment with contaminant concentrations greater than the SQOs.	RA 1A, RA 6, RA 7A, RA 9, RA 16, RA 17, RA 18, RA 19A, RA 19B, RA 20, RA 21, RA 22, and the sheen source removal area in RA 12
Slope Cap	Placement of a minimum of 18 inches of slope cap filter material composed of imported sand and gravel (i.e., 100 percent passing the 6-inch sieve size, 35 to 65 percent passing the No. 4 sieve size, and 15 to 45 percent passing the No. 10 sieve size) from an upland quarry as a confining layer, followed by placement of a minimum of 18 inches of armoring (i.e., riprap or quarry spalls), followed by placement of habitat mix on the surface of the armoring layer. Habitat mix is composed of an imported sand and gravel (i.e., 100 percent passing the 2-inch sieve size, 40 to 60 percent passing the No. 4 sieve size, and 30 to 50 percent passing the No. 10 sieve size) supplied by an upland quarry.	RA 1B, RA 3, RA 5, RA 8, RA 14, RA 19A, RA 19B, and RA 20

Table 1-1
Summary of Completed Remedial Actions, Descriptions, and Remedial Areas

Action	Action Description	Remedial Areas (RA)
Grout Mat Cap	A mat placed to confine sediment with contaminant concentrations greater than the SQOs that is composed of one or two 6-inch-thick layers of concrete, established by injecting grout into a fabric sheath that has been placed over a remedial area.	RA 3, RA 19A, and RA 19B
Thin-Layer Sand Cap	Placement of a thin layer (i.e., 6 inches) of clean material (i.e., channel sand cap material) following dredging to return this area back to the original mudline elevation and to cover remaining elevated sediment concentrations for metals on the post-dredge surface.	Murray Morgan Bridge Remedial Action Area
Habitat Enhancement[1]	Modification to an existing shoreline area to enhance habitat development that may include constructing a benched area at a specific elevation, modifying the substrate, and/or installing large woody debris and/or plants.	RA 8, RA 20, and at the head of the Thea Foss Waterway
Slope Rehabilitation[1]	Removal of anthropogenic debris (e.g., concrete, piling, etc.) and/or placement of import material (e.g., armoring, habitat mix, etc.) to stabilize, flatten, and/or provide more suitable habitat.	RA 10, RA 11, RA 13, and RA 15

Note:

1 Completed action was not constructed for chemical containment and is not included in Long-Term Monitoring Plan remedial action cap integrity monitoring requirements.

Table 1-2
LTMP Monitoring Activities and Schedule

Monitoring Activity	Monitoring Year (Calendar Year)		
	Year 12 (2018)	Year 17 (2023)	Year 22 (2028)
Remedial Area Monitoring			
Natural Recovery and Enhanced Natural Recovery Monitoring at Select Stations – Focused Chemical and Bioassay Testing of Sediments (0 to 10 cm)	X[1]		
Subtidal Cap Hydrographic Survey for Cap Physical Integrity Performance Monitoring	X	X	X
Low-Tide Slope Cap Inspections for Cap Physical Integrity Performance Monitoring	X	X	X
Waterway Source Monitoring			
Contaminant Monitoring of Sediments (0 to 10 cm) at Waterway Source Stations	X	X	X
Confined Disposal Facility Monitoring			
Performance Monitoring – Surface and Groundwater Monitoring and CDF Berm and Cap Inspections	X	X	X
Habitat Mitigation/Restoration Area Monitoring			
Qualitative Site Evaluations of Habitat Mitigation and Enhancement Sites	X	X	X
Low-Tide Slope Rehabilitation Area Visual Inspections	X	X	X

Note:

1 Based on the results of the Year 12 natural recovery and enhanced natural recovery monitoring, natural recovery and enhanced natural recovery monitoring are no longer required during future LTMP monitoring events (refer to Sections 2.2 and 2.3).

Abbreviations:

CDF Confined disposal facility
cm Centimeters
LTMP Long-Term Monitoring Plan

Table 1-3
Actual and Projected Long-Term Monitoring Costs

Cost Category	Monitoring Year (Calendar Year) Costs		
	Year 12 (2018) Actual	Year 17 (2023) Projected	Year 22 (2028) Projected
Consultant Costs			
LTMP Event Activities and Reporting – Floyd Snider and David Evans and Associates	$188,000	--	--
City of Tacoma Costs			
Staff	$40,000	--	--
Laboratory	$16,000	--	--
Total	**$244,000**	**$250,000**	**$250,000**

Abbreviation:
LTMP Long-Term Monitoring Plan

Table 2-1
Comparison of Year 12 Natural Recovery and Enhanced Natural Recovery DEHP Samples Results to DEHP Criteria and Bioassay Testing Decision

Year 12 Sample Name[1]	Year 12 Total Organic Carbon (mg/kg)	Year 12 Total Organic Carbon (%)	Year 12 DEHP (µg/kg)[1]	Year 12 DEHP (mg/kg)	Year 12 DEHP OC Normalized (mg/kg OC)[2]	Further Testing Required?
NR-07-Y12	23,300	2.33	965	0.965	41	No—SQO and SQS criteria met
NR-11-Y12	25,600	2.56	**1,480**	1.48	**58**	Yes—Bioassay
NR-11-Y12-2[3]	24,600	2.46	**1,400**	1.4	**57**	No—duplicate of NR-11-Y12
NR-12-Y12	24,000	2.40	1,210	1.21	**50**	No—SQO criterion met
NR-16-Y12	25,800	2.58	1,240	1.24	**48**	No—SQO criterion met
NR-20-Y12	30,200	3.02	**2,410**	2.41	**80**	Yes—Bioassay

Notes:

1 DEHP dry-weight concentrations (shown in bold and shaded) exceed the DEHP SQO criterion of 1,300 µg/kg.
2 DEHP OC-normalized concentrations (shown in bold and red) exceed the DEHP SQS criterion of 47 mg/kg OC.
3 Sample NR-11-Y12-2 is the field duplicate collected from Station NR-11.

Abbreviations:

DEHP bis(2-ethylhexyl)phthalate
µg/kg Micrograms per kilogram
mg/kg Milligrams per kilogram
OC Organic carbon
SQO Sediment Quality Objective
SQS Sediment quality standard

Table 2-2a
Interpretation of *Eohaustorius* Test Data from Exposure to Marine Sediments[1]

Sample Description	Percent Mortality (Mean ± SD)	Significantly Higher than the Reference Sediment at α=0.05?	Percent Higher (Absolute) than Reference Sediment	Exceedance Under SCO?[2]	Exceedance Under One-Test Criteria for CSL[3]
Control (NAS #6220G)	4.0 ± 4.2	---	---	---	---
NR-11-Y12 (NAS #6216G)	23.0 ± 11.5	YES	19.0	NO	NO
NR-20-Y12 (NAS #6217G)	5.0 ± 5.0	NO	1.0	NO	NO
CIR-02-Y12 (NAS #6218G)*	4.0 ± 5.5	---	---	---	---
CIR-03-Y12 (NAS #6219G)*	4.0 ± 5.5	---	---	---	---

Notes:

* Reference sediments. Test sediment NR-11-Y12 was compared to CIR-03-Y12 and test sediment NR-20-Y12 was compared to CIR-20-Y12.

1 Table sourced from Northwestern Aquatic Sciences' Summary Report of Test 889-1 through 889-3, published August 21, 2018.

2 SCO exceedance if the test sediment mean mortality is >25% and significantly different ($p \leq 0.05$) from the reference sediment mean mortality.

3 CSL exceedance if the test sediment mean mortality is significantly greater than ($p \leq 0.05$) the reference sediment mean mortality and the absolute difference between the test and reference sediment is greater than or equal to 30%.

Abbreviations:

CSL Cleanup screening level
SCO Sediment cleanup objective
SD Standard deviation

Table 2-2b
Interpretation of *Neanthes* Test Data from Exposure to Marine Sediments[1]

Sample Description	Individual Ash-Free Growth Rate (mg/day/worm)	Statistically Significantly Lower than Reference Sediment at α=0.05?	Percent of Reference Sediment	Exceedance Under SCO?[2] ($MIG_T/MIG_R<0.70$)	Exceedance Under One-Test Criteria for CSL?[3] ($(MIG_T)/MIG_R<0.50$)
Control (NAS #6220G)	0.60 ± 0.07	---	---	---	---
NR-11-Y12 (NAS #6216G)	0.74 ± 0.08	NO	116	NO	NO
NR-20-Y12 (NAS #6217G)	0.66 ± 0.10	NO	98.5	NO	NO
CIR-02-Y12 (NAS #6218G)*	0.67 ± 0.13	---	---	---	---
CIR-03-Y12 (NAS #6219G)*	0.64 ± 0.09	---	---	---	---

Notes:

Pupae were not included in the sample to estimate ash-free dry weight (as per EPA/600/R 99/064, p. 59, Section 12.3.8.2).

* Reference sediments. Test sediment NR-11-Y12 was compared to CIR-03-Y12 and test sediment NR-20-Y12 was compared to CIR-20-Y12.

1 Table sourced from Northwestern Aquatic Sciences' *Summary Report of Test 889-1 through 889-3*, published August 21, 2018.

2 SCO exceedance if the test sediment mean growth is significantly less than (1-tailed t-test at $p \leq 0.05$) the reference sediment mean growth, and the difference is >30%.

3 CSL exceedance (one-test criteria) if the test sediment mean individual growth in significantly less than (1-tailed t-test at $p \leq 0.05$) the reference sediment mean growth, and the difference is >50%.

Abbreviations:

CSL Cleanup screening level
mg Milligram
MIG Mean individual growth rate (expressed in the mg/individual/day on an ash-free, dry weight basis)
R Reference Sample
SCO Sediment cleanup objective
T Test sample

Table 2-2c
Interpretation of *Mytilus galloprovincialis* Test Data from Exposure to Marine Sediments[1]

Sample Description	Proportion of Control	Significantly Less Than the Normalized Reference Sediment at $\alpha = 0.10$	$(N_R - N_T)/N_C$†	Exceedance Under SCO?[2] (>0.15 and Significantly Different from Reference)	Exceedance Under One-Test Criteria for CSL[3] (>0.30 and Significantly Different from Reference)
Seawater control	--	---	--	---	---
NR-11-Y12 (NAS #6216G)	0.93	NO	-0.07	NO	NO
NR-20-Y12 (NAS #6217G)	0.98	NO	0.03	NO	NO
CIR-02-Y12 (NAS #6218G)*	1.01	---	--	---	---
CIR-03-Y12 (NAS #6219G)*	0.86	---	--	---	---

Notes:

* Reference sediments. Test sediment NR-11-Y12 was compared to CIR-03-Y12 and test sediment NR-20-Y12 was compared to CIR-02-Y12.

1 Table sourced from Northwestern Aquatic Sciences' *Summary Report of Test 889-1 through 889-3*, published August 21, 2018.

2 SCO exceedance if the mean number of normal survivors in the test sediment when normalized to the control is significantly less than ($p \leq 0.10$) the mean number of normal survivors in the reference sediment when normalized to the control, and the difference between the mean number of normal survivors in the test sediment and that of the reference when normalized to the control is >0.15.

3 CSL exceedance (one-test criteria) if the mean number of normal survivors in the test sediment when normalized to the control is significantly less than ($p \leq 0.10$) the mean number of normal survivors in the reference sediment when normalized to the control, and the difference between the mean number of normal survivors in the test sediment and that of the reference when normalized to the control is >0.30.

† Where N_R = number normal live larvae in reference sediment; N_T = number normal live larvae in test sediment; and N_C = number of normal live larvae in the control.

Abbreviations:

CSL Cleanup screening level
SCO Sediment cleanup objective

Table 2-3
Year 12 Summary of LTMP Focused Low-Tide Slope Cap Inspection Areas

Remedial Area (RA)	Focused Cap Inspection Area	Approximate Linear Feet of Shoreline to Inspect	Summary of Intertidal Cap Construction in Inspection Area[1]	Summary of Focused Cap Inspection Area Conditions During Previous Inspections and the LTMP Year 12 Inspection
1B	Northern portion of slope cap (Monitoring Intervals RA-1B-3 through RA-1B-5)	300	Slope cap	Significant wave action during winter storms may have caused some movement of slope cap material in the northern half of this Remedial Area (Monitoring Intervals RA-1B-3 through RA-1B-5) over the last 12 years of monitoring, based on multiple observations (some potential downslope movement of riprap, missing sampling stakes, and changes to the surface of the habitat mix bench in places). However, based on the Year 12 focused inspection observations, the cap in the northern half of RA 1B appears to have remained intact and the integrity of the cap does not appear to be affected. This conclusion is supported by a comparison of the results from the subtidal hydrographic surveys completed over the years in RA 1B, which have shown consistent elevations in this area over time, including the most recent comparison of Year 10 and Year 12 subtidal hydrographic survey results. Additionally, a total of thirteen piling ends were present at the surface of the slope in two of the monitoring intervals (Monitoring Intervals RA-1B-4 and RA-1B-5) during the Year 12 inspection. Previous inspections have also noted numerous piling ends present in these two monitoring intervals; however, the number of piling ends observed has varied over time. This variation in the number of observed piling ends between the inspection years is likely attributable to these piling ends being difficult to identify as they blend in well with the riprap and slope. During the Year 12 inspection, three of these piling ends were observed cutoff near the cap surface close to the waterline, and these same three piling ends were also observed during previous inspections, indicating that the cap material has not been eroding over time in this area. The other ten piling ends observed in Year 12 were located in the upper riprap slope in these two monitoring intervals, which was not part of the constructed slope cap area, but rather part of the pre-existing riprap armoring on this slope. No settlement or erosion is apparent in this upper riprap slope. These piling ends do not appear to be impacting the integrity of the cap or containment of the underlying contaminated sediments.
3	Grout mat (Portions of Monitoring Intervals RA-3-2 and RA-3-3)	150	Grout mat cap	Eight, and possibly nine, holes were observed on the surface of the grout mat, located in Monitoring Intervals RA-3-2 and RA-3-3, during the Year 12 inspection. One of the holes observed had increased in size relative to previous inspection observations and is 10 to 12 inches in diameter. This hole extends through both layers of the grout mat fabric, with no grout visible between the fabric layers. Two of the other holes previously observed in the Year 10 inspection appeared as depressions, and not holes, on the grout mat surface during the Year 12 inspection. The size of the depressions in these two places does not appear to have increased substantially over the past 2 years. One of the grout mat holes is located above the apparent high water line and does not appear to have increased in size over time. Five of the observed holes are small (generally 2 inches in diameter or smaller) and were not previously observed during the Year 10 inspection. One previous hole observed during the Year 10 inspection was not observed during the Year 12 inspection and may be hidden below algae present on the surface of the grout mat. During both the Year 10 and Year 12 inspections, it was also observed that the fabric surface of the grout mat, above the apparent high water line, appears to be frayed in places with the grout underneath visible but still intact, suggesting possible weathering of the fabric due to rain and sun exposure. Despite the increase in the number of holes and the increase in size of at least one of the holes over time, as well as the fraying of the fabric near the top of the grout mat, these issues do not appear to be impacting the containment of the underlying contaminated sediments at this time. A supplemental inspection of the grout mat conditions was performed in Fall 2018 to assess potential repair options for the grout mat holes.
8	Slope cap area surrounding Outfall 230 (Northern portion of Monitoring Interval RA-8-2)	50	Slope cap[2]	Some downslope movement of the slope cap has occurred off the mouth of Outfall 230 in the past, but this area has remained relatively stable over the last 5 years based on observations made during the Year 7, Year 10, and Year 12 inspections. During the Year 4 inspection by this outfall, it was observed that riprap had moved downslope of a sandy area, located below the waterline, off the mouth of the outfall. During the Year 7 inspection, this sandy area was still present, but the riprap farther downslope was not observed, suggesting that either this riprap had been covered over with sand and gravel coming out of the outfall or had moved farther downslope. In Year 10, there were no apparent changes observed in the vicinity of Outfall 230 above the waterline in comparison to the Year 7 inspection, but turbidity in the water during the Year 10 inspection made observations below the waterline impossible. The slope conditions off the mouth of the outfall observed during the Year 12 inspection was comparable to those observed during the Year 7 and Year 10 inspections, indicating that this area has been relatively stable over the past 5 years. Some possible downslope movement of quarry spalls on the steep slope on the southern side of the Outfall 230 splash pad was noted; however, this change appeared to be minor and the slope cap remains intact in this area.
8	Slope cap in portion of Monitoring Interval RA-8-10	50	Slope cap	In the central portion of Monitoring Interval RA-8-10, seven piling ends and exposed geotextile were observed near the waterline at the surface of this slope cap area during the Year 12 inspection. This area was first observed during the Year 4 inspection and there appeared to be some additional downslope movement of riprap near these pilings between the Year 4 and Year 7 inspections exposing additional geotextile. However, minimal additional downslope movement was apparent when comparing observations from the Year 7, Year 10, and Year 12 inspections, based on the amount of geotextile exposed on the slope and the heights of the piling ends above the slope cap surface. These observations indicate that this area has remained relatively stable over the past 5 years.

Table 2-3
Year 12 Summary of LTMP Focused Low-Tide Slope Cap Inspection Areas

Remedial Area (RA)	Focused Cap Inspection Area	Approximate Linear Feet of Shoreline to Inspect	Summary of Intertidal Cap Construction in Inspection Area[1]	Summary of Focused Cap Inspection Area Conditions During Previous Inspections and the LTMP Year 12 Inspection
Sheen Source Removal Area	Sheen Source Removal Area (Monitoring Interval Sheen Source-1)	65	Channel sand cap	A slight milky blue sheen was observed on the surface of puddles of water at the base of this capped slope area during the Year 7, Year 10, and Year 12 inspections; however, no sheen was observed on the sediment surface. A similar sheen was also noted on the water surface on other portions of the Wheeler-Osgood Waterway's northern shoreline, from west of the Sheen Source Removal Area to the mouth of the waterway during the Year 12 slope rehabilitation inspections in this area. The source and nature of the sheen could not be determined. Two wipe samples containing this sheen were collected from within the slope rehabilitation areas along this shoreline on August 9, 2018, for chemical analysis, with one of these wipe samples collected just west of the Sheen Source Removal Area. Both of these sheen wipe samples had no detections for polychlorinated biphenyls or diesel- or oil-range total petroleum hydrocarbons, but did appear to have trace amounts of select polycyclic aromatic hydrocarbons detected.

Notes:

1 The summary of cap construction, as described below, reflects post-remediation action conditions and will serves as the basis for comparison to information recorded during the focused low-tide slope cap inspections. As-built conditions for slope caps are as follows:
Slope Cap: 18 inches of filter material (sand, gravel), overlain by 18 inches of riprap, overlain by habitat mix (placed at 25 tons per 1,000 square feet).
Grout Mat Cap: Two 6-inch-thick grout mats with no additional material cover.
Channel Sand Cap: 3 feet of channel sand cap material.

2 In 2008 (prior to the Year 2 inspection), maintenance activities on the slope cap near Outfall 230 were performed to remove some exposed geotextile fabric and reconstruct the slope cap beneath and on the south side of the outfall's concrete splash pad. Beneath the outfall splash pad, 18 inches of filter material was placed, overlain by 18 inches of light riprap, overlain by habitat mix. On the south side of the outfall, 18 inches of filter material was placed, overlain by 18 inches of quarry spalls, overlain by habitat mix.

Abbreviation:
LTMP Long Term Monitoring Plan

Table 2-4
Year 12 RA 3 Grout Mat Supplemental Inspection Observations

Area	Monitoring Interval	Observations made during 10/05/18 Inspection[1,2]		Observations made during 6/13/18 Inspection[3]	
		Issue Observed	Additional Notes	Issue Observed	Additional Notes
RA 3	RA-3-2	2x3-inch hole		Not observed at time of 6/13/18 inspection	
		3x2.5-foot soft spot[4]		Not observed at time of 6/13/18 inspection	
		1x8-foot long area of geotextile fabric degredation[5]		Not observed at time of 6/13/18 inspection	
		6x8-inch hole, 2 inches deep		Not observed at time of 6/13/18 inspection	
		Two 1-inch holes		Not observed at time of 6/13/18 inspection	
		8x8-inch soft spot		Not observed at time of 6/13/18 inspection	
		3x6-inch hole, 3 inches deep		<1-inch-diameter hole	
		18x18-inch mortar patch	Hole appears to have been filled with mortar on two separate repair attempts. A vertical crack runs through the center of the mortar patch. Several cracks in the grout mat are visible on the slope above the patch, measuring 18 inches, 2 feet, and 1 foot across.	12-inch-diameter hole	Visible as a depression on the grout mat surface
		4x20-inch hole, 4 inches deep		Not observed at time of 6/13/18 inspection	
		10-inch x 1-foot mortar patch	Mortar patch in good condition, geotextile fabric degraded observed 1-foot below patch	12-inch-diameter hole	Visible as depressions on the grout mat surface
		2x6-inch holes, 2 inches deep		<1-inch-diameter hole	
		2x6-inch holes, 3 inches deep		<1-inch-diameter hole	
		1x2-foot mortar patch	Mortar patch in good condition, geotextile fabric on grout mat surface missing in 2x4-foot section beneath patch	10- to 12-inch-diameter hole	Extending through both layers of the grout mat fabric with no grout visible between the fabric layers
		8x6-inch mortar patch	Mortar patch in good condition	4-inch hole	visible as a depression
		24x16-inch soft spot, with small mortar patch below	Mortar patch in good condition	Not observed at time of 6/13/18 inspection	
		3x4-foot area of geotextile fabric degradation with small chips in the grout mat present		Not observed at time of 6/13/18 inspection	
		2x2-inch hole, 1 inch deep		Not observed at time of 6/13/18 inspection	
		2x2-foot area with frayed geotextile fabric and cracks in the underlying grout.		Not observed at time of 6/13/18 inspection	
		4x4-inch hole, 9 inches deep	Hole does not appear to extend into second layer of mat, observation made in area between gangways under boat lift	Not observed at time of 6/13/18 inspection	
		2x2-inch hole, 1 inch deep	Observation made in area between gangways under boat lift	Not observed at time of 6/13/18 inspection	
	RA-3-3	5x3-inch hole, 2 inches deep		3-inch-diameter	Above PVC pipe
		4x12-inch mortar patch	Mortar patch in good condition	4x12-inch hole	Grout intact
		18x12-inch mortar patch	Area under pipes adjacent to gangway patched, mortar patch in good condition	Not observed at time of 6/13/18 inspection	
		2x2-foot area of cracked concrete		Not observed at time of 6/13/18 inspection	
		17x16-inch soft spot	Void underneath mat surface	Not observed at time of 6/13/18 inspection	
		4x8-inch hole, 2 inches deep		Not observed at time of 6/13/18 inspection	
		6x6-inch hole, 1 inch deep		Possible 1x3-inch hole	
		8x6-inch hole, 4 inches deep	The hole continues 2 inches under the surface of the fabric 7 inches to the west and 20 inches to the south	Not observed at time of 6/13/18 inspection	
		8x6-inch hole, 1 inch deep	Shallow hole/area of geotextile fabric degradation	Not observed at time of 6/13/18 inspection	
		3x2-foot area of geotextile fabric degradation	5-foot horizontal crack extends through this area	Not observed at time of 6/13/18 inspection	
		4x4-foot area of geotextile fabric degradation with chipping of grout (1/8" deep)	3-foot horizontal crack observed on slope just below this area	Not observed at time of 6/13/18 inspection	

Notes:

1 The 10/5/18 inspection was performed by IO Environmental under the field direction of Floyd|Snider and included walking out onto the grout mat slope with fall protection, performing limited marine growth removal as needed to evaluate damage, and making measurements and observations on holes and any additional damage that was observed.

2 Summary of observations is presented from south to north along the mat, see approximate locations of observations on Monitoring Interval Diagrams included in Appendix D.

3 The 6/13/18 inspection was conducted visually from the floating docks located off the toe of the slope and from the top of the slope.

4 Soft spots are areas where the geotextile fabric on top of the mat appeared competent, but the mat buckled when weight was applied.

5 Geotextile fabric degradation describes areas where the grout mats geotextile form is either frayed or no longer present.

Table 3-1
Year 12 Waterway Source Monitoring Sediment Sample Results

		Station	WS-1		WS-2		WS-3		WS-4		WS-5		WS-6		WS-7	
		Sample ID	WS-01-Y12		WS-02-Y12		WS-03-Y12		WS-04-Y12		WS-05-Y12		WS-06-Y12		WS-07-Y12	
		Sample Date	6/5/2018	Sample to SQO Ratio	6/4/2018	Sample to SQO Ratio	6/4/2018	Sample to SQO Ratio	6/5/2018	Sample to SQO Ratio	6/5/2018	Sample to SQO Ratio	6/4/2018	Sample to SQO Ratio	6/4/2018	Sample to SQO Ratio
		Sample Depth	0 to 10 cm		0 to 10 cm		0 to 10 cm		0 to 10 cm		0 to 10 cm		0 to 10 cm		0 to 10 cm	
Parameter	Units	SQO														
Conventionals																
Total Organic Carbon	mg/kg	NC	23,300	NA	24,000	NA	19,100	NA	24,000	NA	30,200	NA	32,100	NA	50,500	NA
Total Organic Carbon	%	NC	2.33	NA	2.40	NA	1.91	NA	2.40	NA	3.02	NA	3.21	NA	5.05	NA
Total Solids	%	NC	47.7	NA	56.5	NA	56.8	NA	54.0	NA	63.4	NA	48.2	NA	44.2	NA
Grain Size																
Gravel (>2,000 µm)	%	NC	0.2	NA	0.6	NA	0.8	NA	6.8	NA	0.4	NA	2.7	NA	3.7	NA
Very Coarse Sand (1,000–2,000 µm)	%	NC	1.0	NA	1.0	NA	1.4	NA	7.2	NA	1.7	NA	3.4	NA	5.0	NA
Coarse Sand (500–1,000 µm)	%	NC	1.0	NA	4.1	NA	1.7	NA	18.0	NA	12.4	NA	4.4	NA	12.3	NA
Medium Sand (250–500 µm)	%	NC	0.8	NA	9.8	NA	5.3	NA	19.0	NA	33.2	NA	7.9	NA	14.1	NA
Fine Sand (125–250 µm)	%	NC	1.1	NA	10.1	NA	13.0	NA	5.4	NA	21.3	NA	6.7	NA	5.7	NA
Very Fine Sand (62.5–125 µm)	%	NC	3.1	NA	7.7	NA	11.3	NA	1.9	NA	8.3	NA	3.8	NA	1.9	NA
Coarse Silt (31–6.25 µm)	%	NC	8.6	NA	3.7	NA	6.3	NA	1.5	NA	3.8	NA	8.6	NA	2.8	NA
Medium Silt (15.6–31 µm)	%	NC	19.5	NA	10.0	NA	12.3	NA	8.2	NA	4.0	NA	9.9	NA	18.1	NA
Fine Silt (7.8–15.6 µm)	%	NC	19.0	NA	13.0	NA	13.7	NA	6.6	NA	3.8	NA	16.8	NA	14.3	NA
Very Fine Silt (3.9–7.8 µm)	%	NC	13.7	NA	10.2	NA	9.3	NA	5.1	NA	2.7	NA	4.3	NA	1.3	NA
Clay (2–3.9 µm)	%	NC	8.0	NA	8.4	NA	8.9	NA	9.8	NA	2.5	NA	15.5	NA	8.3	NA
Clay (1–2 µm)	%	NC	11.4	NA	10.1	NA	4.4	NA	2.8	NA	2.8	NA	5.2	NA	3.2	NA
Clay (<1 µm)	%	NC	12.7	NA	11.3	NA	11.7	NA	7.7	NA	3.0	NA	10.7	NA	9.3	NA
Total Fines (<62.5 µm)	%	NC	92.8	NA	66.7	NA	66.6	NA	41.7	NA	22.6	NA	71.1	NA	57.3	NA
Metals																
Arsenic	mg/kg	57	9.74	0.17	10.2	0.18	7.28	0.13	10.6	0.19	7.37	0.13	11.5	0.20	8.28	0.15
Cadmium	mg/kg	5.1	0.597	0.12	0.655	0.13	0.500 U	NA	0.766	0.15	0.671	0.13	0.730	0.14	0.856	0.17
Copper	mg/kg	390	75.5	0.19	80.0	0.21	56.5	0.14	111	0.28	83.2	0.21	102	0.26	74.7	0.19
Lead	mg/kg	450	39.3	0.09	162	0.36	38.2	0.08	45.0	0.10	61.6	0.14	63.6	0.14	82.6	0.18
Nickel	mg/kg	140	19.6	0.14	20.1	0.14	16.6	0.12	22.0	0.16	20.7	0.15	22.9	0.16	23.3	0.17
Silver	mg/kg	6.1	0.500 U	NA	0.604	0.10	0.500 U	NA	0.500 U	NA	0.500 U	NA	0.767	0.13	0.700	0.11
Zinc	mg/kg	410	130	0.32	127	0.31	81.5	0.20	161	0.39	250	0.61	188	0.46	197	0.48
Mercury	mg/kg	0.59	0.163	0.28	0.191	0.32	0.157	0.27	0.102	0.17	0.091	0.15	0.233	0.39	0.199	0.34
Semivolatile Organic Compounds																
HPAHs																
Benzo(a)anthracene	µg/kg	1,600	396	0.25	445	0.28	352	0.22	241	0.15	435	0.27	503	0.31	703	0.44
Benzo(a)pyrene	µg/kg	1,600	520	0.33	575	0.36	486	0.30	316	0.20	476	0.30	755	0.47	945	0.59
Benzofluoranthenes (total)[1]	µg/kg	3,600	975	0.27	1,250	0.35	857	0.24	693	0.19	897	0.25	1,570	0.44	2,270	0.63
Benzo(g,h,i)perylene	µg/kg	720	350	0.49	333	0.46	331	0.46	211	0.29	313	0.43	549	0.76	954	1.33
Chrysene	µg/kg	2,800	625	0.22	835	0.30	495	0.18	378	0.14	567	0.20	725	0.26	1,110	0.40
Dibenz(a,h)anthracene	µg/kg	230	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	119	0.52	189	0.82
Fluoranthene	µg/kg	2,500	762	0.30	875	0.35	656	0.26	420	0.17	742	0.30	1,010	0.40	1,730	0.69
Indeno(1,2,3-c,d)pyrene	µg/kg	690	326	0.47	319	0.46	309	0.45	193	0.28	258	0.37	477	0.69	856	1.24
Pyrene	µg/kg	3,300	1,130	0.34	1,240	0.38	946	0.29	641	0.19	1,080	0.33	1,360	0.41	1,740	0.53
Total HPAH[2]	µg/kg	17,000	5,080	0.30	5,870	0.35	4,430	0.26	3,090	0.18	4,770	0.28	7,070	0.42	10,500	0.62
Phthalates																
Dimethyl phthalate	µg/kg	160	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA
Diethyl phthalate	µg/kg	200	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA
Di-n-butyl phthalate	µg/kg	1,400	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA
Butyl benzyl phthalate	µg/kg	900	125	0.14	197	0.22	122	0.14	110	0.12	330	0.37	220	0.24	1,050	1.17
Bis(2-ethylhexyl)phthalate	µg/kg	1,300	965	0.74	1,210	0.93	628	0.48	1,130	0.87	2,410	1.85	1,540	1.18	7,590	5.84
Di-n-octyl phthalate	µg/kg	6,200	100 U	NA	100 U	NA	100 U	NA	100 U	NA	107	0.02	110	0.02	199	0.03

Notes:
Concentrations highlighted in red exceed the SQO.
1 Only the benzo(b,k)flouranthene isomer was reported and is included in this total.
2 Total HPAH results have been rounded to three significant figures.

Abbreviations:
cm Centimeters
HPAH High molecular weight polycyclic aromatic hydrocarbons
µg/kg Micrograms per kilogram
µm Micrometer
mg/kg Milligrams per kilogram
NA Not applicable
NC No SQO criterion
SQO Sediment Quality Objective

Qualifier:
U Not detected at the given reporting limit.

Table 3-1
Year 12 Waterway Source Monitoring Sediment Sample Results

Station			WS-8		WS-9		WS-10		WS-11		WS-12			
Sample ID			WS-08-Y12		WS-09-Y12		WS-10-Y12		WS-11-Y12		WS-12-Y12		WS-12-Y12-2	
Sample Date			6/4/2018	Sample to	6/4/2018	Sample to	6/4/2018	Sample to	6/4/2018	Sample to	6/4/2018	Sample to	6/4/2018	Sample to
Sample Depth			0 to 10 cm	SQO Ratio	0 to 10 cm	SQO Ratio	0 to 10 cm	SQO Ratio	0 to 10 cm	SQO Ratio	0 to 10 cm	SQO Ratio	0 to 10 cm	SQO Ratio
Parameter	**Units**	**SQO**												
Conventionals														
Total Organic Carbon	mg/kg	NC	110,000	NA	29,100	NA	44,800	NA	35,700	NA	28,700	NA	25,600	NA
Total Organic Carbon	%	NC	11.0	NA	2.91	NA	4.48	NA	3.57	NA	2.87	NA	2.56	NA
Total Solids	%	NC	33.6	NA	57.4	NA	40.4	NA	68.4	NA	74.9	NA	72.9	NA
Grain Size														
Gravel (>2,000 μm)	%	NC	5.7	NA	0.1	NA	9.8	NA	44.7	NA	33.5	NA	34.8	NA
Very Coarse Sand (1,000–2,000 μm)	%	NC	6.8	NA	0.5	NA	6.6	NA	8.9	NA	10.9	NA	10.6	NA
Coarse Sand (500–1,000 μm)	%	NC	8.7	NA	1.2	NA	8.7	NA	9.7	NA	15.2	NA	15.9	NA
Medium Sand (250–500 μm)	%	NC	12.2	NA	3.0	NA	8.4	NA	6.9	NA	14.9	NA	13.9	NA
Fine Sand (125–250 μm)	%	NC	10.0	NA	8.5	NA	3.3	NA	2.9	NA	3.6	NA	3.4	NA
Very Fine Sand (62.5–125 μm)	%	NC	9.4	NA	19.7	NA	2.7	NA	1.8	NA	1.1	NA	1.0	NA
Coarse Silt (31–6.25 μm)	%	NC	5.3	NA	10.7	NA	4.2	NA	2.5	NA	0.1	NA	1.8	NA
Medium Silt (15.6–31 μm)	%	NC	10.0	NA	12.0	NA	9.5	NA	4.4	NA	5.2	NA	4.4	NA
Fine Silt (7.8–15.6 μm)	%	NC	10.0	NA	12.6	NA	18.5	NA	5.6	NA	6.5	NA	6.2	NA
Very Fine Silt (3.9–7.8 μm)	%	NC	1.8	NA	7.0	NA	3.4	NA	2.4	NA	0.0	NA	0.1	NA
Clay (2–3.9 μm)	%	NC	9.1	NA	9.3	NA	10.8	NA	3.8	NA	3.8	NA	3.4	NA
Clay (1–2 μm)	%	NC	2.2	NA	4.8	NA	4.4	NA	2.1	NA	1.5	NA	1.3	NA
Clay (<1 μm)	%	NC	8.8	NA	10.6	NA	9.7	NA	4.4	NA	3.7	NA	3.3	NA
Total Fines (<62.5 μm)	%	NC	47.2	NA	67.1	NA	60.6	NA	25.1	NA	20.8	NA	20.5	NA
Metals														
Arsenic	mg/kg	57	19.2	0.34	8.86	0.16	12.6	0.22	9.91	0.17	8.19	0.14	8.19	0.14
Cadmium	mg/kg	5.1	1.99	0.39	0.632	0.12	1.26	0.25	0.987	0.19	0.666	0.13	0.661	0.13
Copper	mg/kg	390	149	0.38	66.4	0.17	96.9	0.25	73.9	0.19	55.9	0.14	54.8	0.14
Lead	mg/kg	450	128	0.28	49.6	0.11	74.0	0.16	66.0	0.15	43	0.10	42.6	0.09
Nickel	mg/kg	140	20.7	0.15	18.6	0.13	28.4	0.20	26.3	0.19	24.2	0.17	24.9	0.18
Silver	mg/kg	6.1	1.85	0.30	0.536	0.09	0.715	0.12	0.562	0.09	0.5 U	NA	0.5 U	NA
Zinc	mg/kg	410	233	0.57	120	0.29	233	0.57	175	0.43	130	0.32	130	0.32
Mercury	mg/kg	0.59	0.423	0.72	0.222	0.38	0.194	0.33	0.174	0.29	0.109	0.18	0.114	0.19
Semivolatile Organic Compounds														
HPAHs														
Benzo(a)anthracene	μg/kg	1,600	1,170	0.73	375	0.23	428	0.27	410	0.26	171	0.11	189	0.12
Benzo(a)pyrene	μg/kg	1,600	1,190	0.74	561	0.35	695	0.43	569	0.36	271	0.17	299	0.19
Benzofluoranthenes (total)[1]	μg/kg	3,600	2,710	0.75	1,140	0.32	1,600	0.44	993	0.28	601	0.17	647	0.18
Benzo(g,h,i)perylene	μg/kg	720	**841**	1.17	530	0.74	**873**	1.21	481	0.67	303	0.42	321	0.45
Chrysene	μg/kg	2,800	1,950	0.70	531	0.19	697	0.25	563	0.20	212	0.08	294	0.11
Dibenz(a,h)anthracene	μg/kg	230	192	0.83	100 U	NA	156	0.68	100 U	NA	100 U	NA	100 U	NA
Fluoranthene	μg/kg	2,500	**3,270**	1.31	794	0.32	1,000	0.40	954	0.38	402	0.16	445	0.18
Indeno(1,2,3-c,d)pyrene	μg/kg	690	**798**	1.16	454	0.66	**712**	1.03	432	0.63	257	0.37	271	0.39
Pyrene	μg/kg	3,300	**4,150**	1.26	1,030	0.31	1,370	0.42	1,220	0.37	548	0.17	600	0.18
Total HPAH[2]	μg/kg	17,000	16,300	0.96	5,420	0.32	7,530	0.44	5,620	0.33	2,770	0.16	3,070	0.18
Phthalates														
Dimethyl phthalate	μg/kg	160	153 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA
Diethyl phthalate	μg/kg	200	153 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA	100 U	NA
Di-n-butyl phthalate	μg/kg	1,400	189	0.14	100 U	NA	109	0.08	100 U	NA	100 U	NA	100 U	NA
Butyl benzyl phthalate	μg/kg	900	557	0.62	226	0.25	882	0.98	162	0.18	137	0.15	112	0.12
Bis(2-ethylhexyl)phthalate	μg/kg	1,300	**2,320**	1.78	**1,740**	1.34	**4,290**	3.30	**1,590**	1.22	**1,350**	1.04	**1,470**	1.13
Di-n-octyl phthalate	μg/kg	6,200	153 U	NA	100 U	NA	225	0.04	110	0.02	100 U	NA	100 U	NA

Notes:
Concentrations highlighted in red exceed the SQO.
1 Only the benzo(b,k)flouranthene isomer was reported and is included in this total.
2 Total HPAH results have been rounded to three significant figures.

Abbreviations:
cm Centimeters
HPAH High molecular weight polycyclic aromatic hydrocarbo
μg/kg Micrograms per kilogram
μm Micrometer
mg/kg Milligrams per kilogram
NA Not applicable
NC No SQO criterion
SQO Sediment Quality Objective

Qualifier:
U Not detected at the given reporting limit.

Table 3-2
Summary of Year 12 Waterway Source Monitoring Sediment Sample Results for DEHP

Sample ID	TOC (mg/kg)	TOC (%)	DEHP (µg/kg)	Exceeds SQO? (1,300 µg/kg)	DEHP (mg/kg-OC)	Exceed SMS SQS? (47 mg/kg-OC)	Sample to SMS SQS Ratio
WS-01-Y12	23,300	2.33	965	No	41.4	No	0.88
WS-02-Y12	24,000	2.40	1,210	No	50.4	Yes	1.07
WS-03-Y12	19,100	1.91	628	No	32.9	No	0.70
WS-04-Y12	24,000	2.40	1,130	No	47.1	Yes	1.002
WS-05-Y12	30,200	3.02	2,410	Yes	79.8	Yes	1.70
WS-06-Y12	32,100	3.21	1,540	Yes	48.0	Yes	1.02
WS-07-Y12	50,500	5.05	7,590	Yes	Not calculated[1]	NA	NA
WS-08-Y12	110,000	11.0	2,320	Yes	Not calculated[1]	NA	NA
WS-09-Y12	29,100	2.91	1,740	Yes	59.8	Yes	1.27
WS-10-Y12	44,800	4.48	4,290	Yes	Not calculated[1]	NA	NA
WS-11-Y12	35,700	3.57	1,590	Yes	Not calculated[1]	NA	NA
WS-12-Y12	28,700	2.87	1,350	Yes	47.0	No	1.00
WS-12-Y12-2[2]	25,600	2.56	1,470	Yes	57.4	Yes	1.22

Notes:

1 TOC is outside the usual range (0.5–3.5%) for OC normalization.

2 Sample WS-12-Y12-2 is the field duplicate for Sample WS-12-Y12.

Abbreviations:

DEHP bis(2-ethylhexyl)phthalate
µg/kg Micrograms per kilogram
mg/kg Milligrams per kilogram
NA Not applicable
OC Organic carbon
SMS Sediment Management Standards
SQO Sediment Quality Objective
SQS Sediment Quality Standard
TOC Total organic carbon

Table 4-1
Summary of Surface Water Analytical Results from the Year 12 (2018) Performance Monitoring

	Station	SWM-01		Aquatic Life Marine Water Chronic Criteria[2]
	Sample ID	SWM-01-061918	SWM-01-0619-B[1]	
	Sample Date	6/19/2018	6/19/2018	
Parameter	Units			
Conventionals				
Conductivity	µS/cm	41.8	41.8	NA
Salinity	ppt	27.7	27.7	NA
Metals Dissolved				
Copper	µg/L	2 U	2.5 U	3.1
Lead	µg/L	2 U	2.5 U	8.1
Nickel	µg/L	2 U	2.5 U	8.2
Zinc	µg/L	2 U	2.5 U	81.0
Mercury	µg/L	0.1 U	0.1 U	0.025
Metals Total				
Mercury	µg/L	0.1 U	0.1 U	0.025

Notes:

Bold Results indicate detected metals concentrations.

1 Sample SWM-01-061918-B is a field duplicate of sample SWM-01-061918.

2 Criteria from WAC 173-201A-240 Table 240.

Abbreviations:

µS/cm Microsiemens per centimeter

µg/L Micrograms per liter

NA Not applicable

ppt Parts per thousand

WAC Washington Administrative Code

Qualifiers:

U Undetected

Table 4-2
Summary of Shallow Groundwater Analytical Results and Baseline Criteria Comparison for Year 4 (2010), Year 7 (2013), Year 10 (2016), and Year 12 (2018) Performance Monitoring

Analytes for Each Performance Well	Units	Baseline Mean	Baseline 95 UTL	2010 Performance Monitoring Results	2013 Performance Monitoring Results	2016 Performance Monitoring Results	2018 Performance Monitoring Results
MW-01							
pH[1]	pH units	6.78	7.4	6.57	6.62	6.66	6.44
Dissolved Oxygen (DO)[1]	mg/L	5.066	11.15	4.1	1.3	0	3.3
Conductivity	µmhos/cm	27,683	42,397	25,540	21,700	24,000	24,100
Salinity	ppt	17.1	27.73	21.2	12.1	15	15.2
Total Organic Carbon (TOC)	mg/L	17.31	102	5.96	13	10 U	2.73
Total Suspended Solids (TSS)	mg/L	15.86	34.69	3.8	1.43	2.35 U	12
Copper Dissolved	µg/L	8.375	14.38	5.7	2.5	2.17	3.22
Nickel Dissolved	µg/L	60.5	396.2	5 U	9.5	10.3	5.59
Zinc Dissolved	µg/L	NA	NA	5 U	29	3.19	7.83
Naphthalene	µg/L	0.023	NA	0.01 U	0.01 U	0.01 UJ	0.012 U
Benzo(g,h,i)perylene[6]	µg/L	NA	NA	0.01 U	0.01	0.01 UJ	0.01 U
Dibenzo(a,h)anthracene6	µg/L	NA	NA	0.01 U	0.012	0.01 UJ	0.01 U
MW-02							
pH[1]	pH units	6.139	6.751	6.15	6.55	6.15	4.04
Dissolved Oxygen (DO)[1]	mg/L	0.949	3.34	1.04	4.46	0.91	1.24
Conductivity	µmhos/cm	14,278	28,224	16,200	14,200	17,400	8,370
Salinity	ppt	7.8	15.45	9.4	7.4	10.4	5.4
Total Organic Carbon (TOC)	mg/L	47.99	195	23.5	41	18.7	46.7
Total Suspended Solids (TSS)	mg/L	107.9	191	176	22.4	28.4	1.27
Copper Dissolved	µg/L	4.25	NA	5 U	1 U	1 U	1 UJ
Nickel Dissolved	µg/L	10.25	22.42	5	6.04	12.6	2.28
Zinc Dissolved	µg/L	NA	NA	22.2	7.4	6.75	1.47
Acenaphthene	µg/L	0.0248	0.0516	0.011 J	0.01 U	0.01 UJ	0.01 U
Anthracene	µg/L	0.0185	NA	0.01 UJ	0.011	0.02	0.015
Fluorene	µg/L	0.0187	NA	0.010 U	0.01 U	0.01 UJ	0.01 U
Naphthalene[2]	µg/L	0.0133	NA	0.020 J	0.01 U	0.011 J	0.012 U
Phenanthrene[3]	µg/L	0.0278	NA	0.012	0.01 U	0.01 UJ	0.01 U
Benzo(a)anthracene	µg/L	0.0305	NA	0.010 U	0.01 U	0.011 J	0.01 U
Benzo(a)pyrene	µg/L	0.0225	NA	0.01 U	0.01 U	0.01 UJ	0.01 U
Benzofluoranthenes (total)	µg/L	0.032	NA	0.02 U	0.02 U	0.021 UJ	0.02 U
Benzo(g,h,i)perylene[4]	µg/L	0.0135	NA	0.01 U	0.017	0.01 UJ	0.01 U
Chrysene	µg/L	0.023	NA	0.01 U	0.01 U	0.01 UJ	0.01 U
Dibenzo(a,h)anthracene[6]	µg/L	NA	NA	0.01 U	0.019	0.01 UJ	0.01 U
Fluoranthene	µg/L	0.0513	0.305	0.025	0.013	0.026	0.01 U
Indeno(1,2,3-cd)pyrene[5]	µg/L	0.011	NA	0.01 U	0.016	0.01 UJ	0.01 U
Pyrene	µg/L	0.0399	0.222	0.021	0.012	0.025	0.01 U

Table 4-2
Summary of Shallow Groundwater Analytical Results and Baseline Criteria Comparison for Year 4 (2010), Year 7 (2013), Year 10 (2016), and Year 12 (2018) Performance Monitoring

Analytes for Each Performance Well	Units	Baseline Mean	Baseline 95 UTL	2010 Performance Monitoring Results	2013 Performance Monitoring Results	2016 Performance Monitoring Results	2018 Performance Monitoring Results
MW-06							
pH[1]	pH units	6.757	8.426	6.46	6.76	6.62	4.12
Dissolved Oxygen (DO)[1]	mg/L	2.821	8.238	6.1	3.41	0.67	1.81
Conductivity	µmhos/cm	30,673	44,392	29,300	31,620	29,100	27,400
Salinity	ppt	19.43	28.34	24.4	18.5	18.5	17.9
Total Organic Carbon (TOC)	mg/L	21	205.7	13.3	10	10 U	15.5 U
Total Suspended Solids (TSS)	mg/L	23.06	120.6	4.8	3.3	7.69	1 U
Copper Dissolved	µg/L	59.88	120.3	87.1	55.6	109	60.6
Nickel Dissolved	µg/L	54.13	121	19.3	24.4	8.2	4.78
Zinc Dissolved	µg/L	446.3	788.8	**894**	580	522	246
2-Methylnaphthalene	µg/L	0.133	NA	0.010 UJ	0.01 U	0.01 UJ	0.01 U
Acenaphthene	µg/L	0.845	NA	0.010 UJ	0.01 U	0.01 UJ	0.01 U
Anthracene	µg/L	0.122	NA	0.010 UJ	0.01 U	0.01 UJ	0.01 U
Fluorene	µg/L	0.399	NA	0.010 U	0.01 U	0.01 UJ	0.01 U
Naphthalene	µg/L	2.188	NA	0.010 UJ	0.01 U	0.01 UJ	0.012 U
Phenanthrene	µg/L	0.39	NA	0.010 U	0.01 U	0.01 UJ	0.01 U
Benzo(a)anthracene	µg/L	0.102	NA	0.01 U	0.01 U	0.01 UJ	0.01 U
Benzo(a)pyrene	µg/L	0.067	NA	0.01 U	0.01 U	0.01 UJ	0.01 U
Benzofluoranthenes (total)	µg/L	0.131	NA	0.02 U	0.01 U	0.02 UJ	0.02 U
Benzo(g,h,i)perylene	µg/L	0.046	NA	0.010 U	0.01 U	0.01 UJ	0.01 U
Chrysene	µg/L	0.118	NA	0.010 U	0.01 U	0.01 UJ	0.01 U
Dibenzo(a,h)anthracene	µg/L	0.011	NA	0.010 U	0.01 U	0.01 UJ	0.01 U
Fluoranthene	µg/L	0.63	NA	0.010 U	0.01 U	0.01 U	0.01 U
Indeno(1,2,3-cd)pyrene	µg/L	0.036	NA	0.010 U	0.01 U	0.01 UJ	0.01 U
Pyrene	µg/L	0.383	NA	0.010 U	0.01 U	0.01 U	0.01 U
MW-10[7]							
pH[1]	pH units	6.507	7.62	6.28	7.16	6.74	4.91
Dissolved Oxygen (DO)[1]	mg/L	0.541	1.177	0.63	**2.02**	0.35	0.02
Conductivity[1]	µmhos/cm	30,011	45,429	27,660	25,460	21,000	4,050
Salinity	ppt	19.28	30.44	23	16.3	12.7	2.4
Total Organic Carbon (TOC)	mg/L	10.76	37.53	6.99	14	10 U	**56.9**
Total Suspended Solids (TSS)	mg/L	40.63	73.63	31.6	18.4	20.3	6.4
Copper Dissolved	µg/L	6.857	8.891	5 U	1 U	1 U	1 UJ
Nickel Dissolved	µg/L	11.63	23.33	5 U	1.88	3.8	1 U
Zinc Dissolved	µg/L	NA	NA	26.8	4.8	1.81	10.8
2-Methylnaphthalene[6]	µg/L	NA	NA	0.010 UJ	0.01 UJ	0.01 UJ	0.169
Acenaphthene	µg/L	0.0136	0.0171	0.010 UJ	0.01 U	0.01 UJ	0.012
Anthracene[6]	µg/L	NA	NA	0.010 UJ	0.01 U	0.01 UJ	0.01
Fluorene[6]	µg/L	NA	NA	0.010 U	0.01 UJ	0.01 UJ	0.015

Table 4-2
Summary of Shallow Groundwater Analytical Results and Baseline Criteria Comparison for Year 4 (2010), Year 7 (2013), Year 10 (2016), and Year 12 (2018) Performance Monitoring

Analytes for Each Performance Well	Units	Baseline Mean	Baseline 95 UTL	2010 Performance Monitoring Results	2013 Performance Monitoring Results	2016 Performance Monitoring Results	2018 Performance Monitoring Results
MW-10[7] (cont.)							
Naphthalene	µg/L	0.02	NA	0.010 UJ	0.01 U	0.01 UJ	0.16
Phenanthrene[6]	µg/L	NA	NA	0.010 U	0.01 UJ	0.01 UJ	0.013
Fluoranthene	µg/L	0.0191	0.0298	0.012	0.01 U	0.01 UJ	0.012
Pyrene	µg/L	0.0141	0.0205	0.010 U	0.01 U	0.01 UJ	0.01 U

Notes:

Bold Results indicate detected concentrations above the baseline 95th UTL.

1 pH, conductivity, and dissolved oxygen measurements were conducted in the field during sampling using a multi-parameter field meter.

2 The maximum naphthalene concentration detected in MW-02 during baseline monitoring was 0.019 µg/L.

3 The maximum phenanthrene concentration detected in MW-02 during baseline monitoring was 0.048 µg/L.

4 The maximum benzo(g,h,i)perylene concentration detected in MW-02 during baseline monitoring was 0.014 µg/L.

5 The maximum indeno(1,2,3-cd)pyrene concentration detected in MW-02 during baseline monitoring was 0.011 µg/L.

6 The analyte was not detected during baseline monitoring for monitoring well MW-10.

7 Four of the polycyclic aromatic hydrocarbons (PAHs) detected in MW-10 did not have baseline performance criteria due to insufficient detections during baseline relative to the reporting limit of 0.01 µg/L. Five of the seven PAHs detected in MW-10 during Year 12 Performance Monitoring were detected at concentrations slightly exceeding the detection limit of 0.01 µg/L.

Abbreviations:

µg/L Micrograms per liter

µmhos/cm Micromhos per centimeter

mg/L Milligrams per liter

MW Monitoring Well

NA Analyte is presented in the table as it was detected at least once during baseline monitoring or performance monitoring; however, there were insufficient detections during baseline monitoring to calculate a baseline 95th UTL.

ppt Parts per thousand

UTL Upper Tolerance Level

Qualifiers:

U Undetected.

UJ Undetected and the associated numerical value is an estimated quantity.

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimate.

Table 4-2
Summary of Shallow Groundwater Analytical Results and Baseline Criteria Comparison for Year 4 (2010), Year 7 (2013), Year 10 (2016), and Year 12 (2018) Performance Monitoring

Analytes for Each Performance Well	Units	Baseline Mean	Baseline 95 UTL	2010 Performance Monitoring Results	2013 Performance Monitoring Results	2016 Performance Monitoring Results	2018 Performance Monitoring Results
MW-10[7] (cont.)							
Naphthalene	µg/L	0.02	NA	0.010 UJ	0.01 U	0.01 UJ	0.16
Phenanthrene[6]	µg/L	NA	NA	0.010 U	0.01 UJ	0.01 UJ	0.013
Fluoranthene	µg/L	0.0191	0.0298	0.012	0.01 U	0.01 UJ	0.012
Pyrene	µg/L	0.0141	0.0205	0.010 U	0.01 U	0.01 UJ	0.01 U

Notes:

Bold Results indicate detected concentrations above the baseline 95th UTL.

1 pH, conductivity, and dissolved oxygen measurements were conducted in the field during sampling using a multi-parameter field meter.

2 The maximum naphthalene concentration detected in MW-02 during baseline monitoring was 0.019 µg/L.

3 The maximum phenanthrene concentration detected in MW-02 during baseline monitoring was 0.048 µg/L.

4 The maximum benzo(g,h,i)perylene concentration detected in MW-02 during baseline monitoring was 0.014 µg/L.

5 The maximum indeno(1,2,3-cd)pyrene concentration detected in MW-02 during baseline monitoring was 0.011 µg/L.

6 The analyte was not detected during baseline monitoring for monitoring well MW-10.

7 Four of the polycyclic aromatic hydrocarbons (PAHs) detected in MW-10 did not have baseline performance criteria due to insufficient detections during baseline relative to the reporting limit of 0.01 µg/L. Five of the seven PAHs detected in MW-10 during Year 12 Performance Monitoring were detected at concentrations slightly exceeding the detection limit of 0.01 µg/L.

Abbreviations:

µg/L Micrograms per liter

µmhos/cm Micromhos per centimeter

mg/L Milligrams per liter

MW Monitoring Well

NA Analyte is presented in the table as it was detected at least once during baseline monitoring or performance monitoring; however, there were insufficient detections during baseline monitoring to calculate a baseline 95th UTL.

ppt Parts per thousand

UTL Upper Tolerance Level

Qualifiers:

U Undetected.

UJ Undetected and the associated numerical value is an estimated quantity.

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimate.

Table 5-1
Summary of Maintenance Activities for Habitat Mitigation and Enhancement Areas

Site	Maintenance Activities
North Beach Habitat	• Minor weeding • Minor trash removal • Check and tighten anchors on large woody debris, as needed
Middle Waterway Tideflat Habitat	• Lock/chain gate mid-site • Remove irrigation shed and other stakes and remaining irrigation system • Minor weeding • Coordinate removal of transient camp mid-site • Check and tighten anchors on large woody debris, as needed
Puyallup River Side Channel	• Minor weeding • Coordinate transient/trash removal • Supplemental planting on pathway on old levee
Hylebos Creek Mitigation Site	• Minor weeding • Check and tighten anchors on large woody debris, as needed • Consider planting willow stakes to help shade out reed canary grass
Johnny's Dock Habitat Enhancement	• Check and tighten anchors on large woody debris, as needed
Head of Thea Foss Shoreline Habitat	• Minor weeding • Check and tighten anchors on logs, as needed
SR 509 Esplanade Riparian Habitat	• Minor weeding • Weedeat around plants
Log Step Habitat Enhancement	• Spot spray blackberry in adjacent area • Check and tighten anchors on logs as needed

Table 5-2
Slope Rehabilitation Sheen Wipe Sample Results

Remedial Area		RA 10		RA 13	
Wipe Sample ID		RA10 Sheen-Y12		RA13 Sheen-Y12	
Sample Date		8/9/2018		8/9/2018	
Parameter	Units				
Conventionals					
Total Organic Carbon	µg/wipe	751		521	
Low Molecular Weight Polycyclic Aromatic Hydrocarbons (LPAHs)					
2-Methylnaphthalene	µg/wipe	0.02	UJ	0.03	UJ
Acenaphthene	µg/wipe	0.01	U	0.01	U
Acenaphthylene	µg/wipe	0.01	U	0.01	U
Anthracene	µg/wipe	0.01	U	0.01	U
Fluorene	µg/wipe	0.01	U	0.01	UJ
Naphthalene	µg/wipe	0.04	UJ	0.04	UJ
Phenanthrene	µg/wipe	0.05	UJ	0.05	UJ
High Molecular Weight Polycyclic Aromatic Hydrocarbons (HPAHs)					
Benzo(a)anthracene	µg/wipe	0.01		0.03	
Benzo(a)pyrene	µg/wipe	0.01		0.03	
Benzo(b,k)fluoranthene	µg/wipe	0.03		0.05	
Benzo(g,h,i)perylene	µg/wipe	0.01		0.03	
Chrysene	µg/wipe	0.02		0.04	
Dibenz(a,h)anthracene	µg/wipe	0.01	U	0.01	U
Fluoranthene	µg/wipe	0.02		0.04	
Indeno(1,2,3-c,d)pyrene	µg/wipe	0.01		0.03	
Pyrene	µg/wipe	0.02		0.06	
Polychlorinated Biphenyls (PCBs)					
Aroclor-1016	µg/wipe	0.4	U	0.4	U
Aroclor-1221	µg/wipe	0.4	U	0.4	U
Aroclor-1232	µg/wipe	0.4	U	0.4	U
Aroclor-1242	µg/wipe	0.4	U	0.4	U
Aroclor-1248	µg/wipe	0.4	U	0.4	U
Aroclor-1254	µg/wipe	0.4	U	0.4	U
Aroclor-1260	µg/wipe	0.4	U	0.4	U

Table 5-2
Slope Rehabilitation Sheen Wipe Sample Results

	Remedial Area	RA 10	RA 13
	Wipe Sample ID	RA10 Sheen-Y12	RA13 Sheen-Y12
	Sample Date	8/9/2018	8/9/2018
Parameter	Units		
Total Petroleum Hydrocarbons (TPH)			
NWTPH-Diesel	mg/wipe	0.1 U	0.1 U
NWTPH-Heavy Oil	mg/wipe	0.2 U	0.2 U

Abbreviations:
mg/wipe Milligrams per wipe
µg/wipe Micrograms per wipe

Qualifiers:
U Not detected at the given reporting limit.
UJ The analyte was analyzed for and not detected, and the associated numerical value is an estimate.

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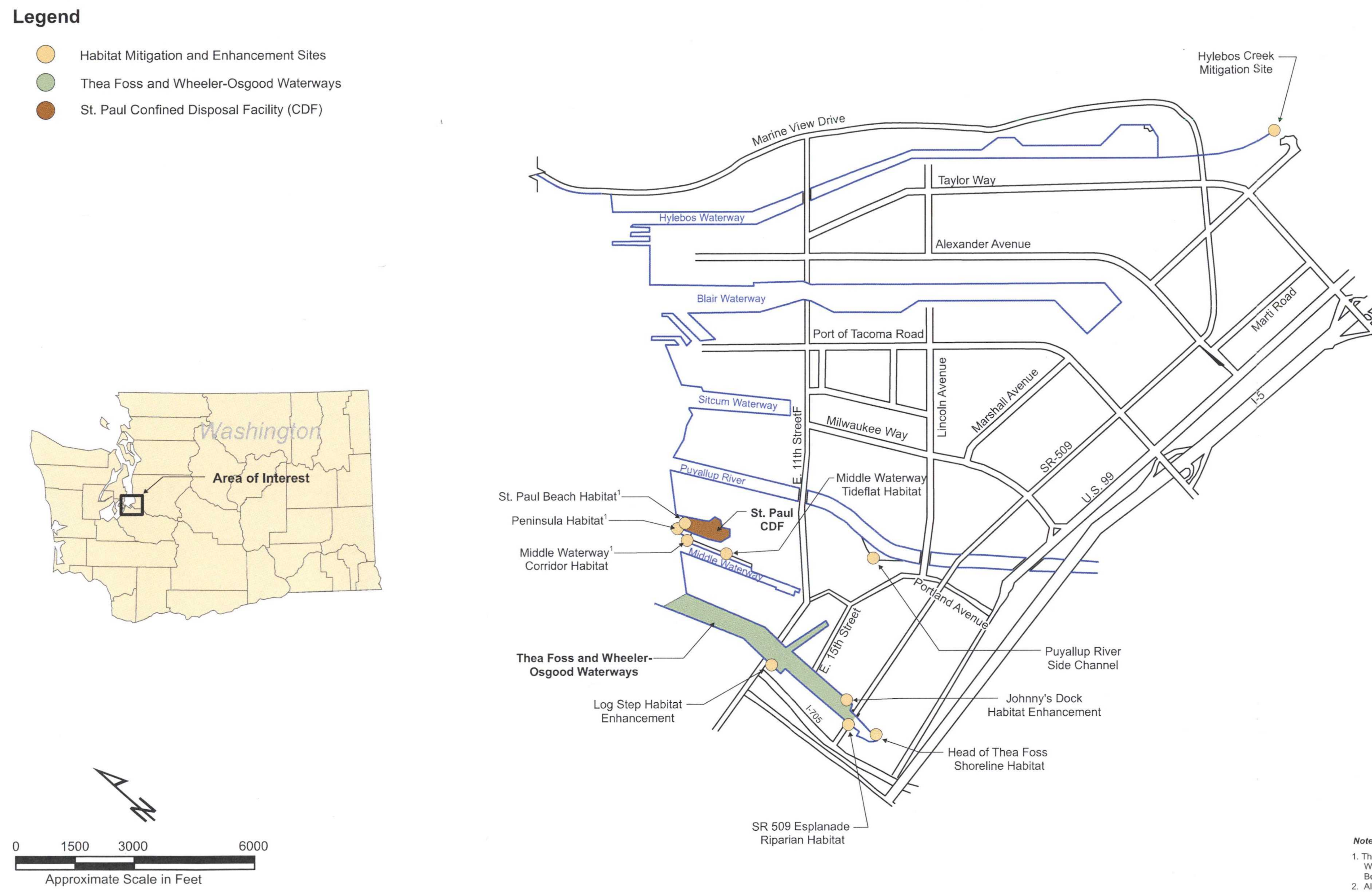
Remediation Project

Year 12 LTMP Monitoring Event Report

Figures



Notes:

1. The St. Paul Beach Habitat, Peninsula Habitat, and the Middle Waterway Corridor Habitat are collectively called the North Beach Habitat.
2. All locations are approximate.

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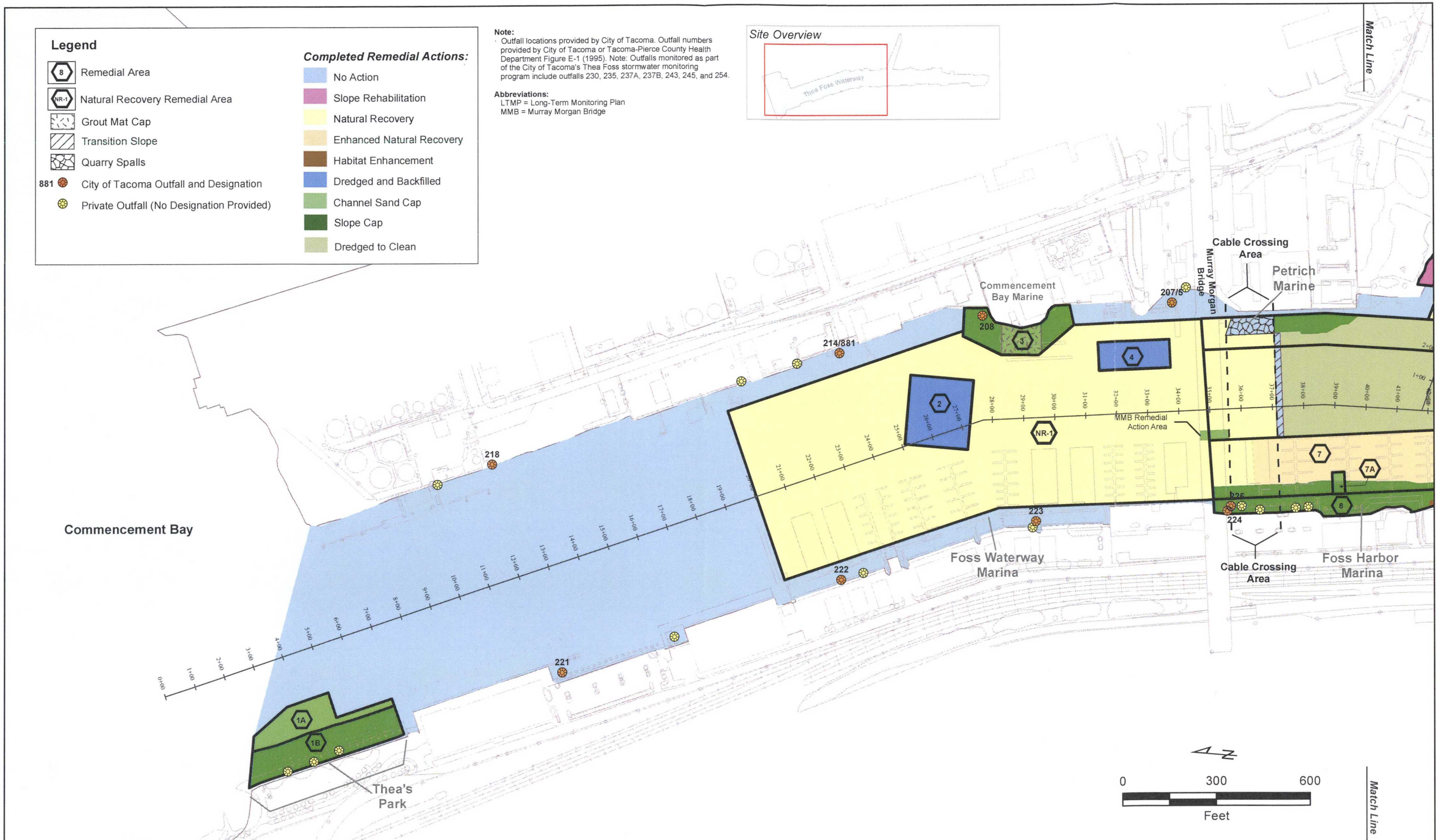
Figure 1-1
Project Location Map

I:\GIS\Projects\COT_ON_CALL\MXD\2017 LTMP\Figure 1-1 Project Location Map.svg
3/30/2017



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Year 12 LTMP Monitoring Event Report

Figure 1-2 (Page 1 of 2)
Completed Remedial Actions

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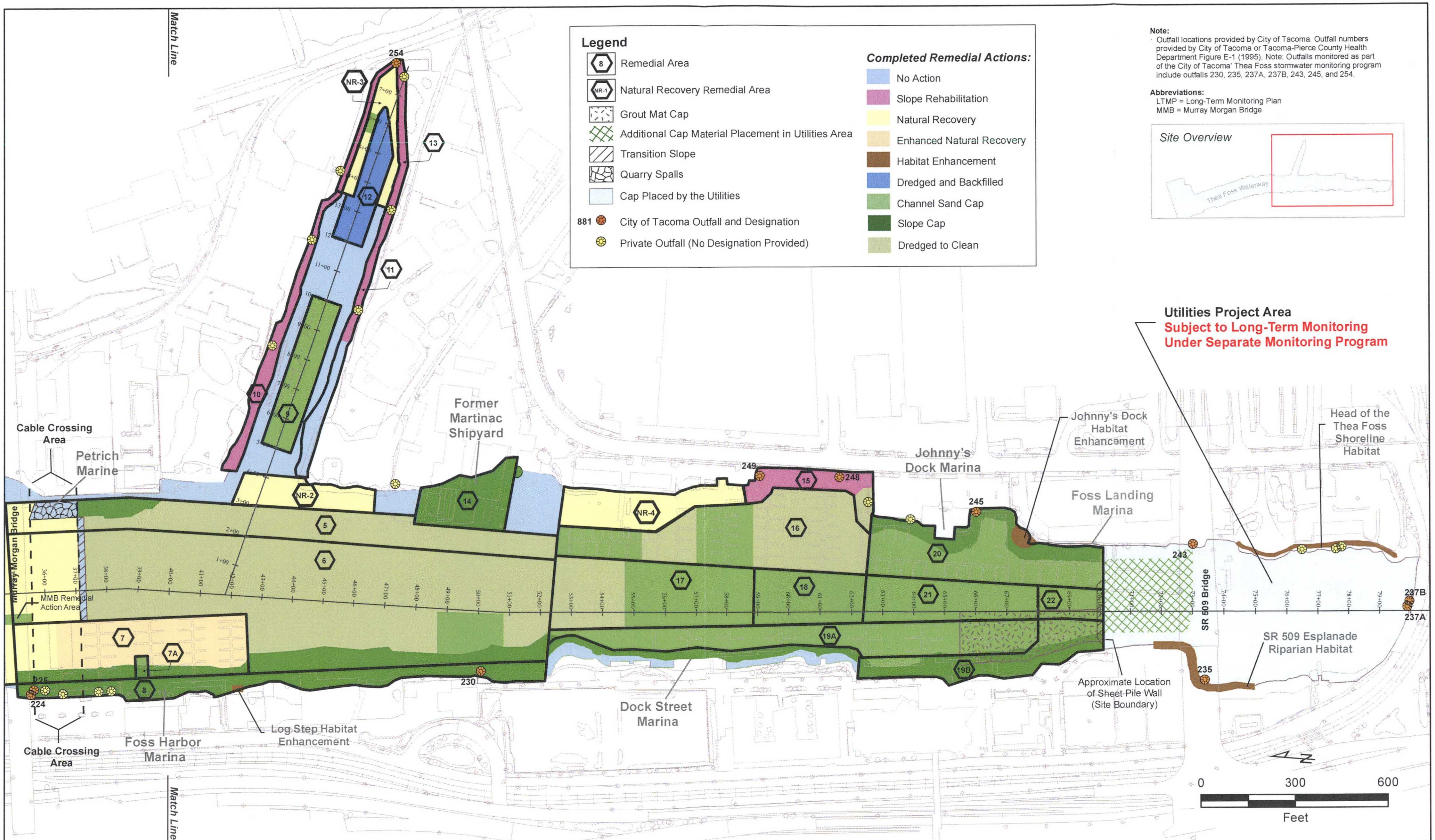

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Figure 1-2 (Page 2 of 2)
Completed Remedial Actions

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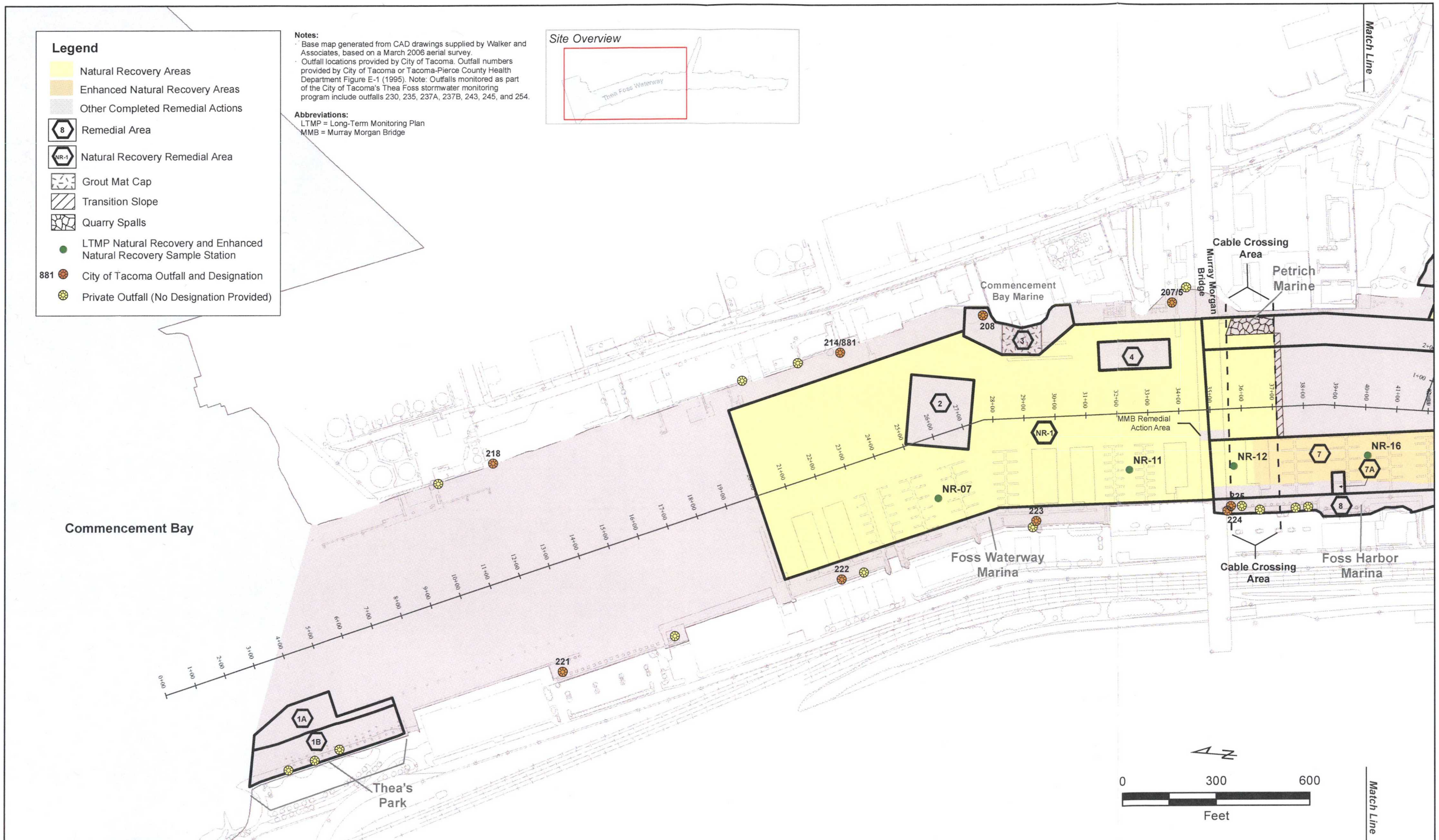

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Figure 2-1 (Page 1 of 2)
Natural Recovery and Enhanced Natural Recovery Sample Stations

File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 2-1 Natural Recovery and Enhanced Natural Recovery Sample Stations (1of2).mxd
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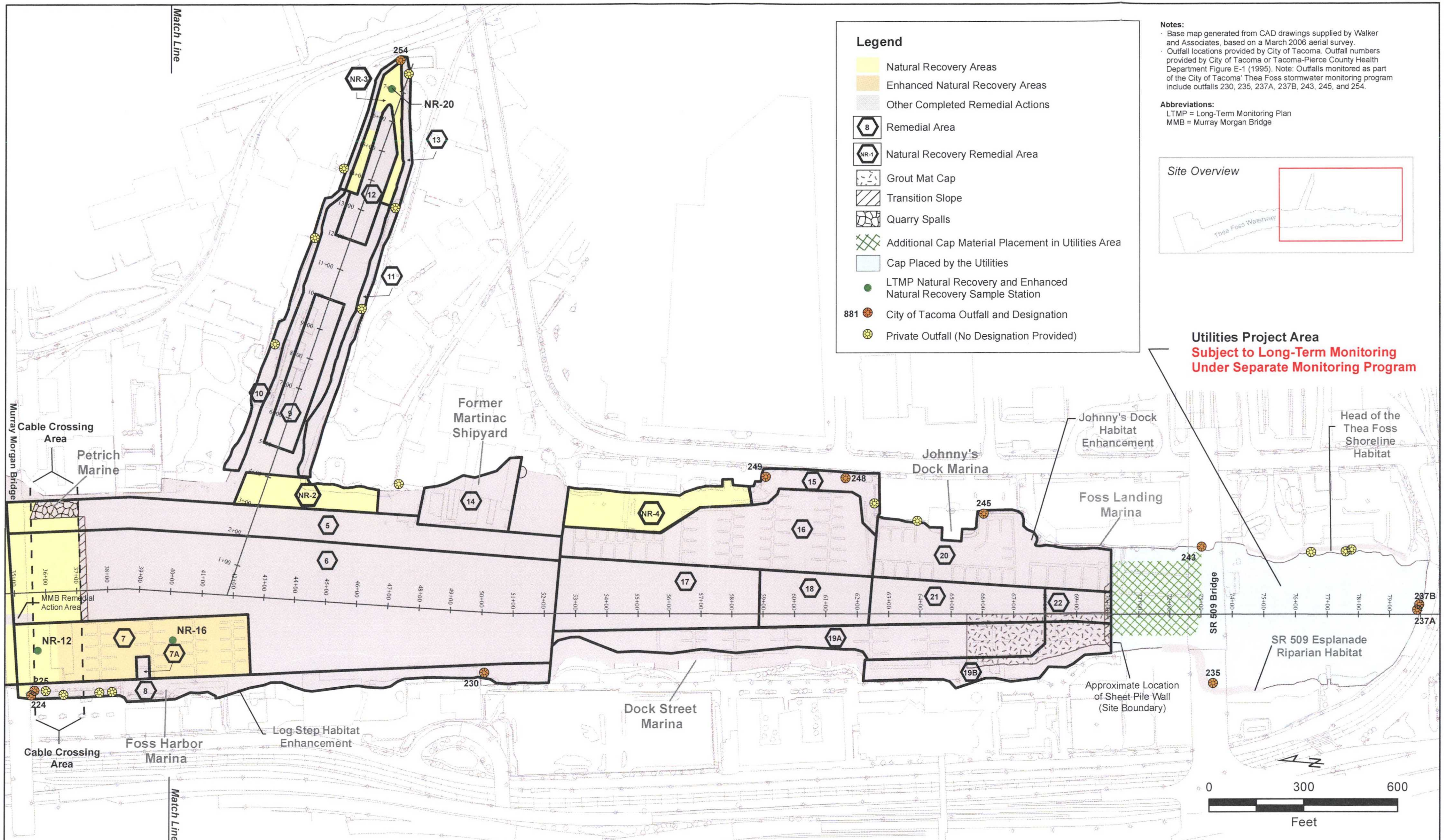

FLOYD | SNIDER strategy • science • engineering	Thea Foss and Wheeler-Osgood Waterways Year 12 LTMP Monitoring Event Report	Figure 2-1 (Page 2 of 2) Natural Recovery and Enhanced Natural Recovery Sample Stations

File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 2-1 Natural Recovery and Enhanced Natural Recovery Sample Stations (2of2).mxd
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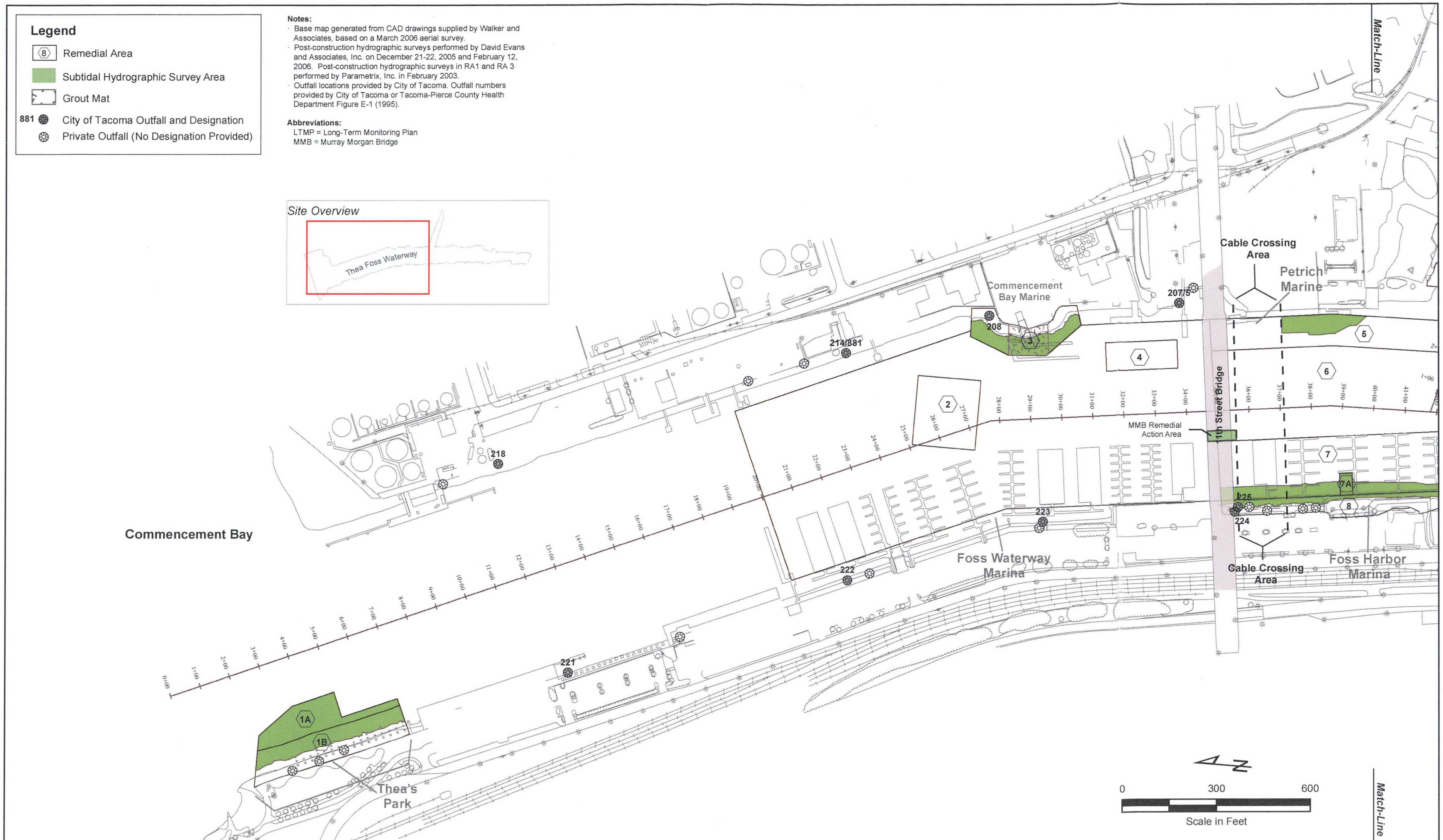

FLOYD | SNIDER strategy • science • engineering	Thea Foss and Wheeler-Osgood Waterways Year 12 LTMP Monitoring Event Report	Figure 2-2 (Page 1 of 2) Subtidal Hydrographic Survey Areas

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9/24/2018

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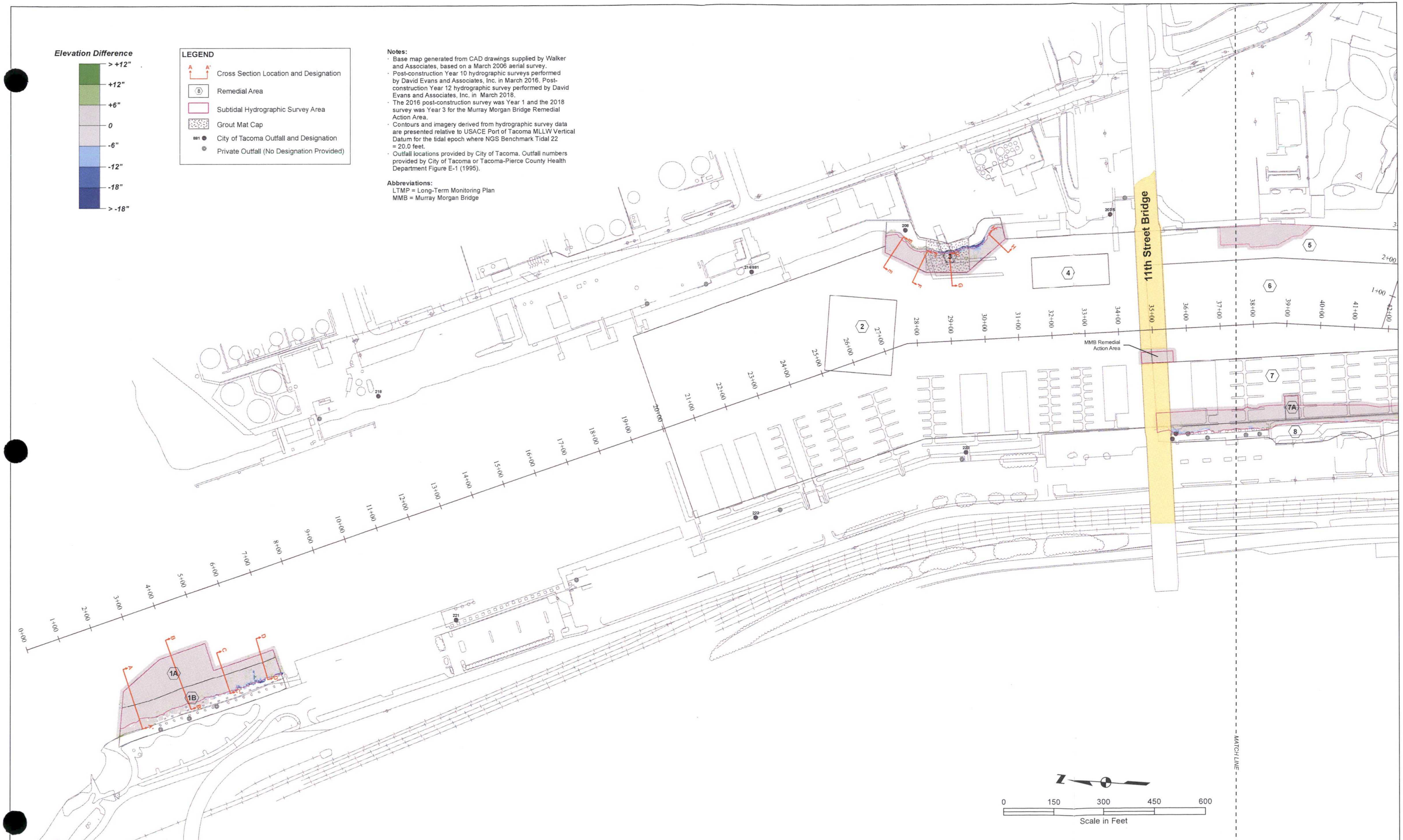
Figure 2-2 (Page 2 of 2)
Subtidal Hydrographic Survey Areas

\\corp.fsmseattle.com\shares\Enterprise\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 2-2 Subtidal Hydrographic Survey Areas (2of2).mxd
9/24/2018



Notes:

- Base map generated from CAD drawings supplied by Walker and Associates, based on a March 2006 aerial survey.
- Post-construction Year 10 hydrographic surveys performed by David Evans and Associates, Inc. in March 2016. Post-construction Year 12 hydrographic survey performed by David Evans and Associates, Inc. in March 2018.
- The 2016 post-construction survey was Year 1 and the 2018 survey was Year 3 for the Murray Morgan Bridge Remedial Action Area.
- Contours and imagery derived from hydrographic survey data are presented relative to USACE Port of Tacoma MLLW Vertical Datum for the tidal epoch where NGS Benchmark Tidal 22 = 20.0 feet.
- Outfall locations provided by City of Tacoma. Outfall numbers provided by City of Tacoma or Tacoma-Pierce County Health Department Figure E-1 (1995).

Abbreviations:

LTMP = Long-Term Monitoring Plan
MMB = Murray Morgan Bridge

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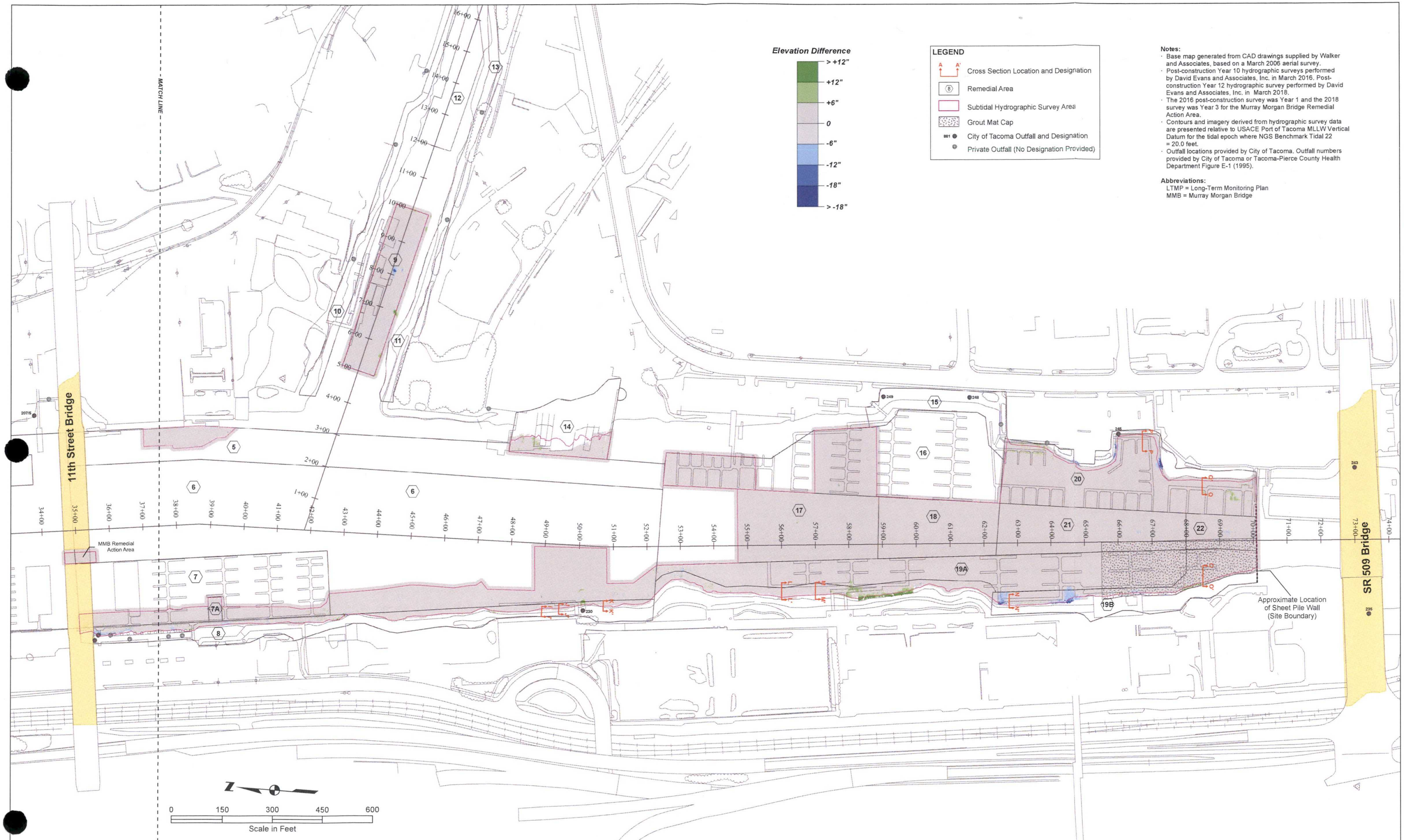
Figure 2-3 (Page 1 of 2)
Comparison of Year 10 (2016) and Year 12 (2018)
Subtidal Hydrographic Survey Results



Notes:

- Base map generated from CAD drawings supplied by Walker and Associates, based on a March 2006 aerial survey.
- Post-construction Year 10 hydrographic surveys performed by David Evans and Associates, Inc. in March 2016. Post-construction Year 12 hydrographic survey performed by David Evans and Associates, Inc. in March 2018.
- The 2016 post-construction survey was Year 1 and the 2018 survey was Year 3 for the Murray Morgan Bridge Remedial Action Area.
- Contours and imagery derived from hydrographic survey data are presented relative to USACE Port of Tacoma MLLW Vertical Datum for the tidal epoch where NGS Benchmark Tidal 22 = 20.0 feet.
- Outfall locations provided by City of Tacoma. Outfall numbers provided by City of Tacoma or Tacoma-Pierce County Health Department Figure E-1 (1995).

Abbreviations:

LTMP = Long-Term Monitoring Plan
MMB = Murray Morgan Bridge

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Figure 2-3 (Page 2 of 2)
Comparison of Year 10 (2016) and Year 12 (2018)
Subtidal Hydrographic Survey Results

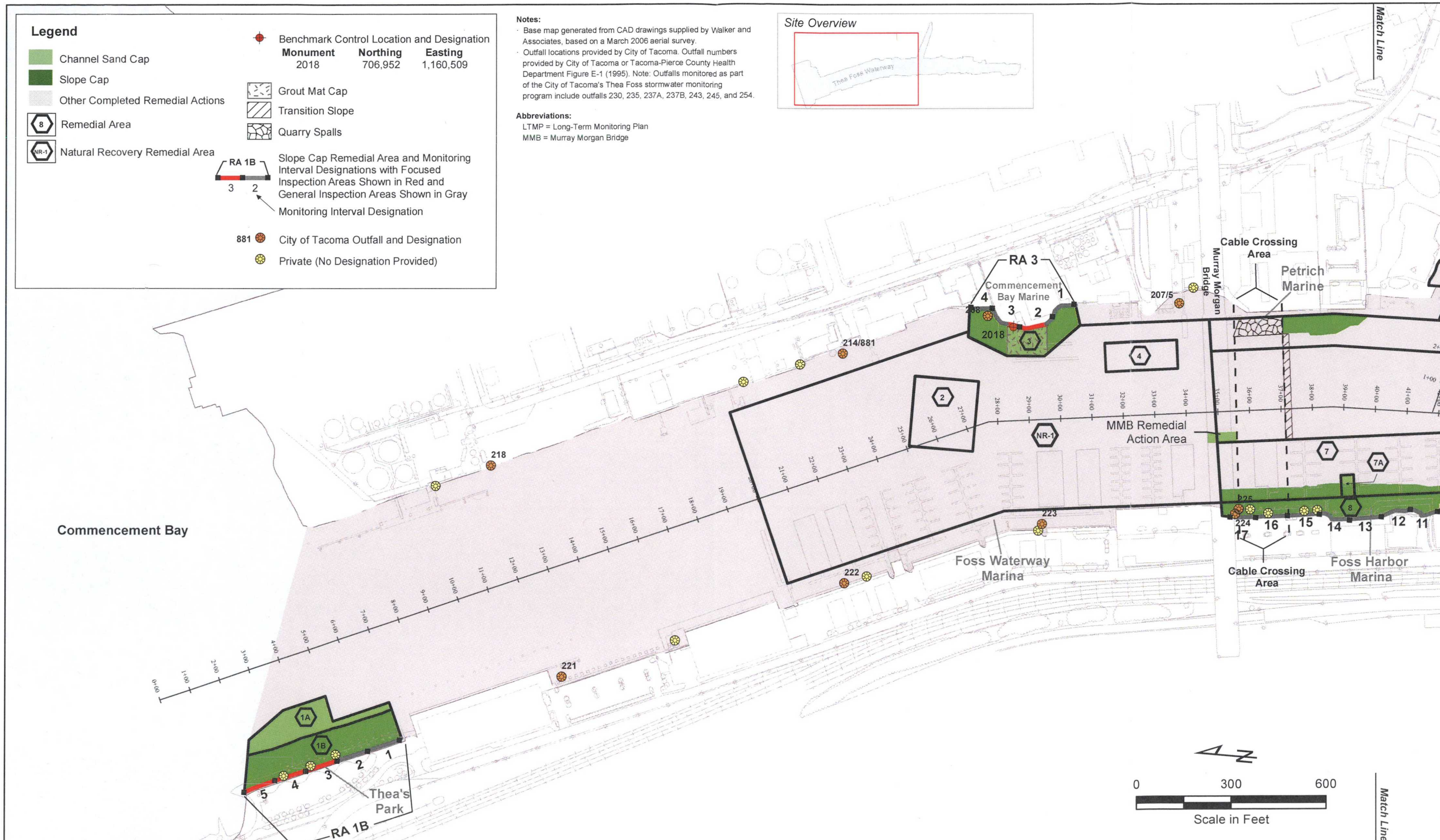

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Figure 2-4 (Page 1 of 2)
Low-Tide Slope Cap Inspection Areas

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File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 2-4 Low-tide Slope Cap Inspection Areas (1of2).mxd
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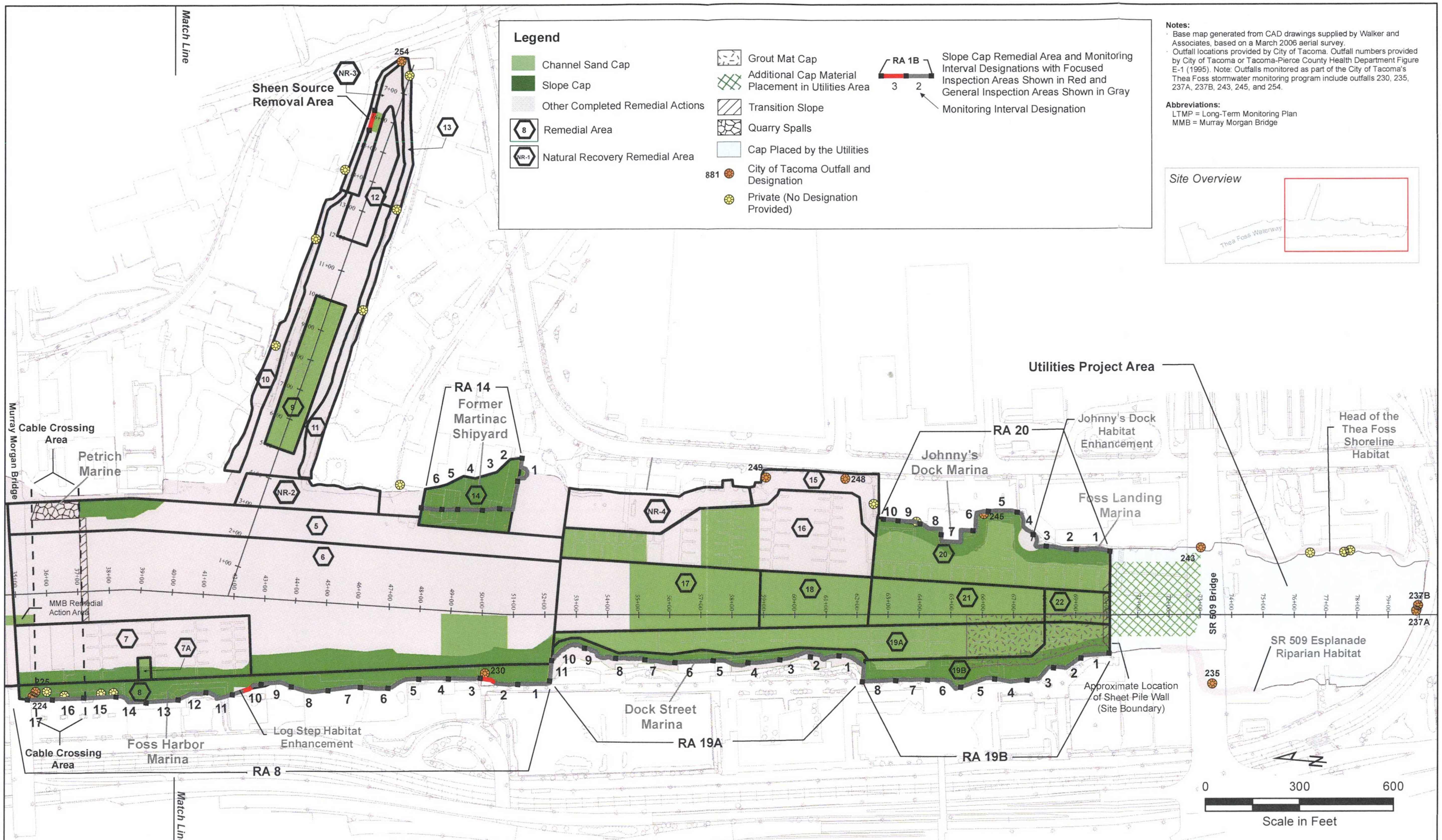

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Figure 2-4 (Page 2 of 2)
Low-Tide Slope Cap Inspection Areas

File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 2-4 Low-tide Slope Cap Inspection Areas (2of2).mxd
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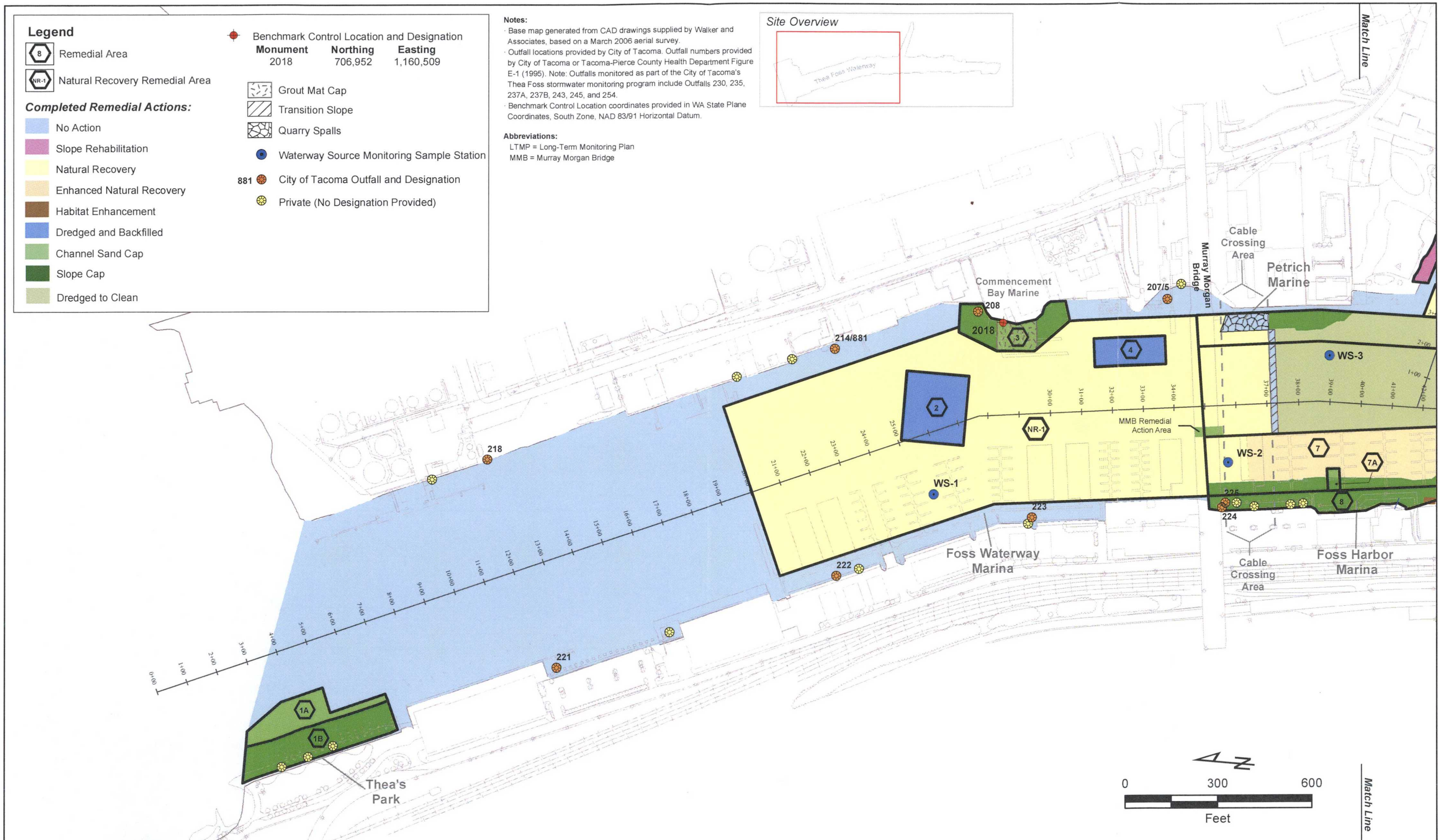

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Figure 3-1 (Page 1 of 2)
Waterway Source Monitoring Sample Stations

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File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 3-1 Waterway Source Monitoring Sample Stations (1of2).mxd
Date: 9/24/2018

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Year 12 LTMP Monitoring Event Report

Figure 3-1 (Page 2 of 2)
Waterway Source Monitoring Sample Stations

File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 3-1 Waterway Source Monitoring Sample Stations (2of2).mxd
Date: 9/24/2018

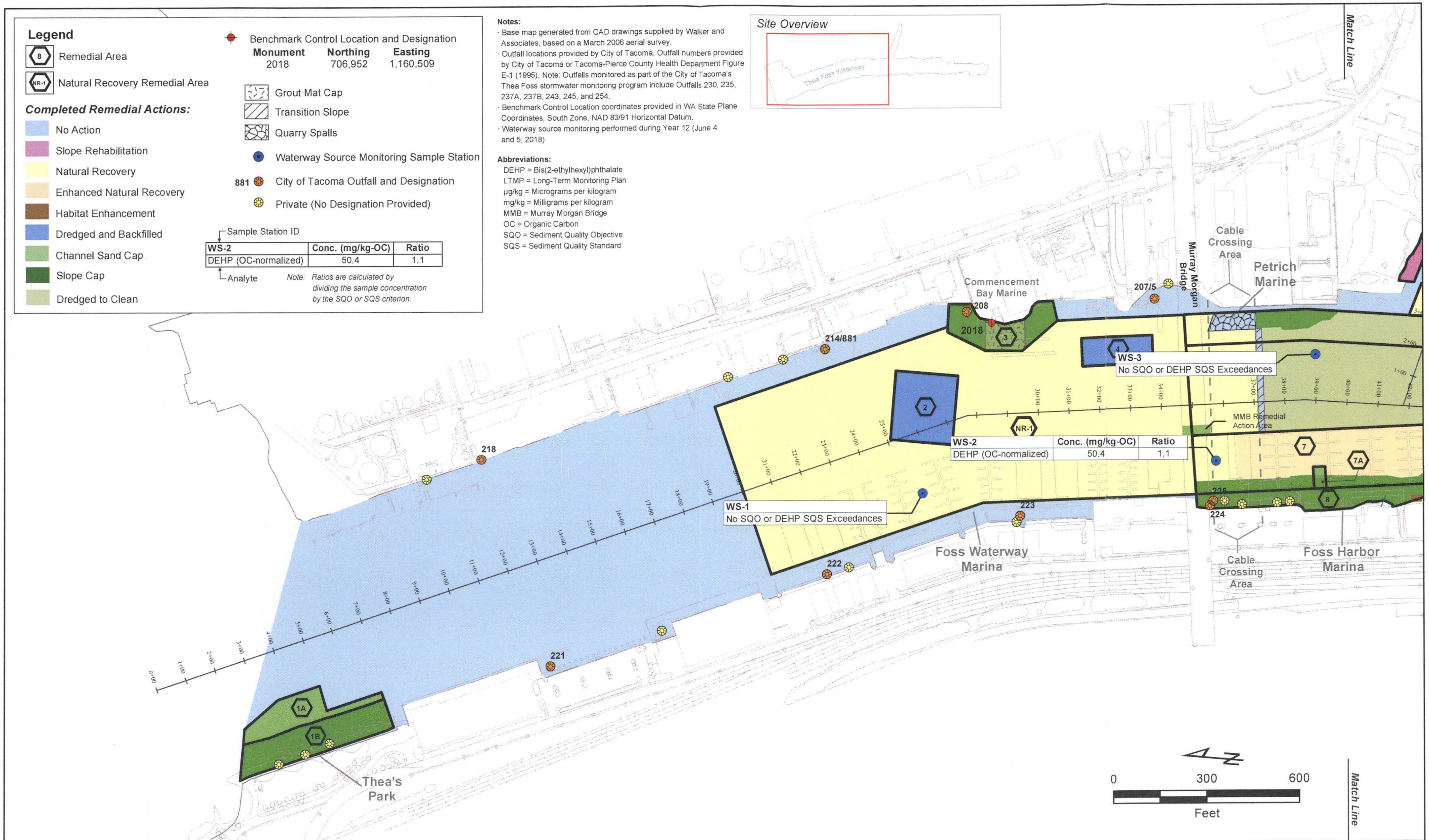

Figure 3-2 (Page 1 of 2)
Year 12 SQO or DEHP SQS Exceedances in Waterway Source Monitoring Surface Sediment Samples

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Year 12 LTMP Monitoring Event Report

File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 3-2 Year 12 SQO or DEHP SQS Exceedances in Waterway Source Monitoring Surface Sediment Samples (1of2).mxd
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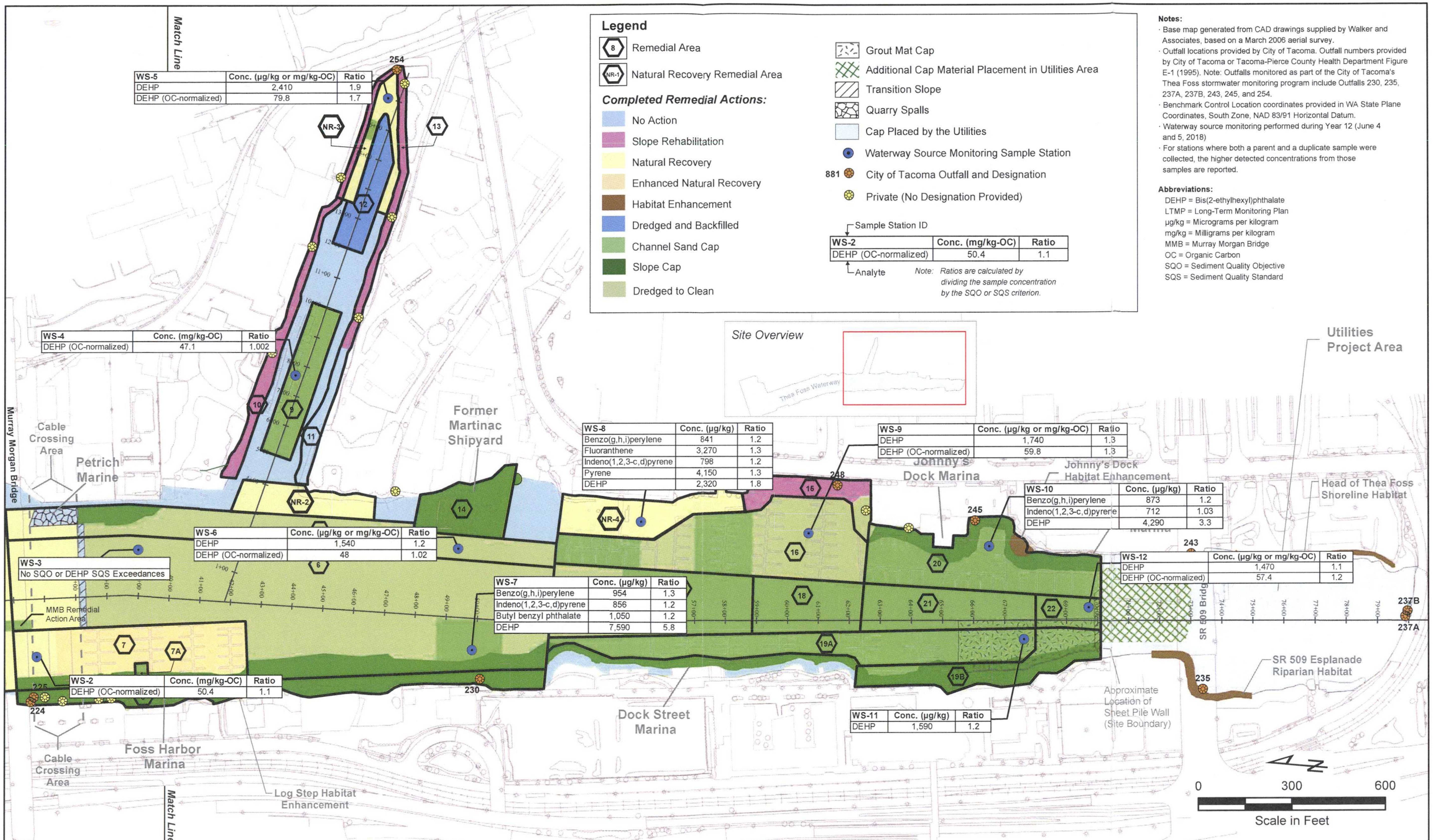

WS-5	Conc. (µg/kg or mg/kg-OC)	Ratio
DEHP	2,410	1.9
DEHP (OC-normalized)	79.8	1.7

WS-4	Conc. (mg/kg-OC)	Ratio
DEHP (OC-normalized)	47.1	1.002

WS-3
No SQO or DEHP SQS Exceedances

WS-6	Conc. (µg/kg or mg/kg-OC)	Ratio
DEHP	1,540	1.2
DEHP (OC-normalized)	48	1.02

WS-2	Conc. (mg/kg-OC)	Ratio
DEHP (OC-normalized)	50.4	1.1

WS-7	Conc. (µg/kg)	Ratio
Benzo(g,h,i)perylene	954	1.3
Indeno(1,2,3-c,d)pyrene	856	1.2
Butyl benzyl phthalate	1,050	1.2
DEHP	7,590	5.8

WS-8	Conc. (µg/kg)	Ratio
Benzo(g,h,i)perylene	841	1.2
Fluoranthene	3,270	1.3
Indeno(1,2,3-c,d)pyrene	798	1.2
Pyrene	4,150	1.3
DEHP	2,320	1.8

WS-9	Conc. (µg/kg or mg/kg-OC)	Ratio
DEHP	1,740	1.3
DEHP (OC-normalized)	59.8	1.3

WS-10	Conc. (µg/kg)	Ratio
Benzo(g,h,i)perylene	873	1.2
Indeno(1,2,3-c,d)pyrene	712	1.03
DEHP	4,290	3.3

WS-11	Conc. (µg/kg)	Ratio
DEHP	1,590	1.2

WS-12	Conc. (µg/kg or mg/kg-OC)	Ratio
DEHP	1,470	1.1
DEHP (OC-normalized)	57.4	1.2

Legend

- 8 Remedial Area
- NR-1 Natural Recovery Remedial Area

Completed Remedial Actions:

- No Action
- Slope Rehabilitation
- Natural Recovery
- Enhanced Natural Recovery
- Habitat Enhancement
- Dredged and Backfilled
- Channel Sand Cap
- Slope Cap
- Dredged to Clean
- Grout Mat Cap
- Additional Cap Material Placement in Utilities Area
- Transition Slope
- Quarry Spalls
- Cap Placed by the Utilities
- Waterway Source Monitoring Sample Station
- 881 City of Tacoma Outfall and Designation
- Private (No Designation Provided)

Sample Station ID

WS-2	Conc. (mg/kg-OC)	Ratio
DEHP (OC-normalized)	50.4	1.1

Analyte

Note: *Ratios are calculated by dividing the sample concentration by the SQO or SQS criterion.*

Notes:

- Base map generated from CAD drawings supplied by Walker and Associates, based on a March 2006 aerial survey.
- Outfall locations provided by City of Tacoma. Outfall numbers provided by City of Tacoma or Tacoma-Pierce County Health Department Figure E-1 (1995). Note: Outfalls monitored as part of the City of Tacoma's Thea Foss stormwater monitoring program include Outfalls 230, 235, 237A, 237B, 243, 245, and 254.
- Benchmark Control Location coordinates provided in WA State Plane Coordinates, South Zone, NAD 83/91 Horizontal Datum.
- Waterway source monitoring performed during Year 12 (June 4 and 5, 2018)
- For stations where both a parent and a duplicate sample were collected, the higher detected concentrations from those samples are reported.

Abbreviations:

DEHP = Bis(2-ethylhexyl)phthalate
LTMP = Long-Term Monitoring Plan
µg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
MMB = Murray Morgan Bridge
OC = Organic Carbon
SQO = Sediment Quality Objective
SQS = Sediment Quality Standard

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Figure 3-2 (Page 2 of 2)
Year 12 SQO or DEHP SQS Exceedances in Waterway Source Monitoring Surface Sediment Samples

File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 3-2 Year 12 SQO or DEHP SQS Exceedances in Waterway Source Monitoring Surface Sediment Samples (2of2).mxd
Date: 9/24/2018

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Figure 4-1
Performance CDF Surface Water and Groundwater Monitoring Locations

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9/24/2018

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Figure 4-2
CDF Berm and Cap Observation Locations

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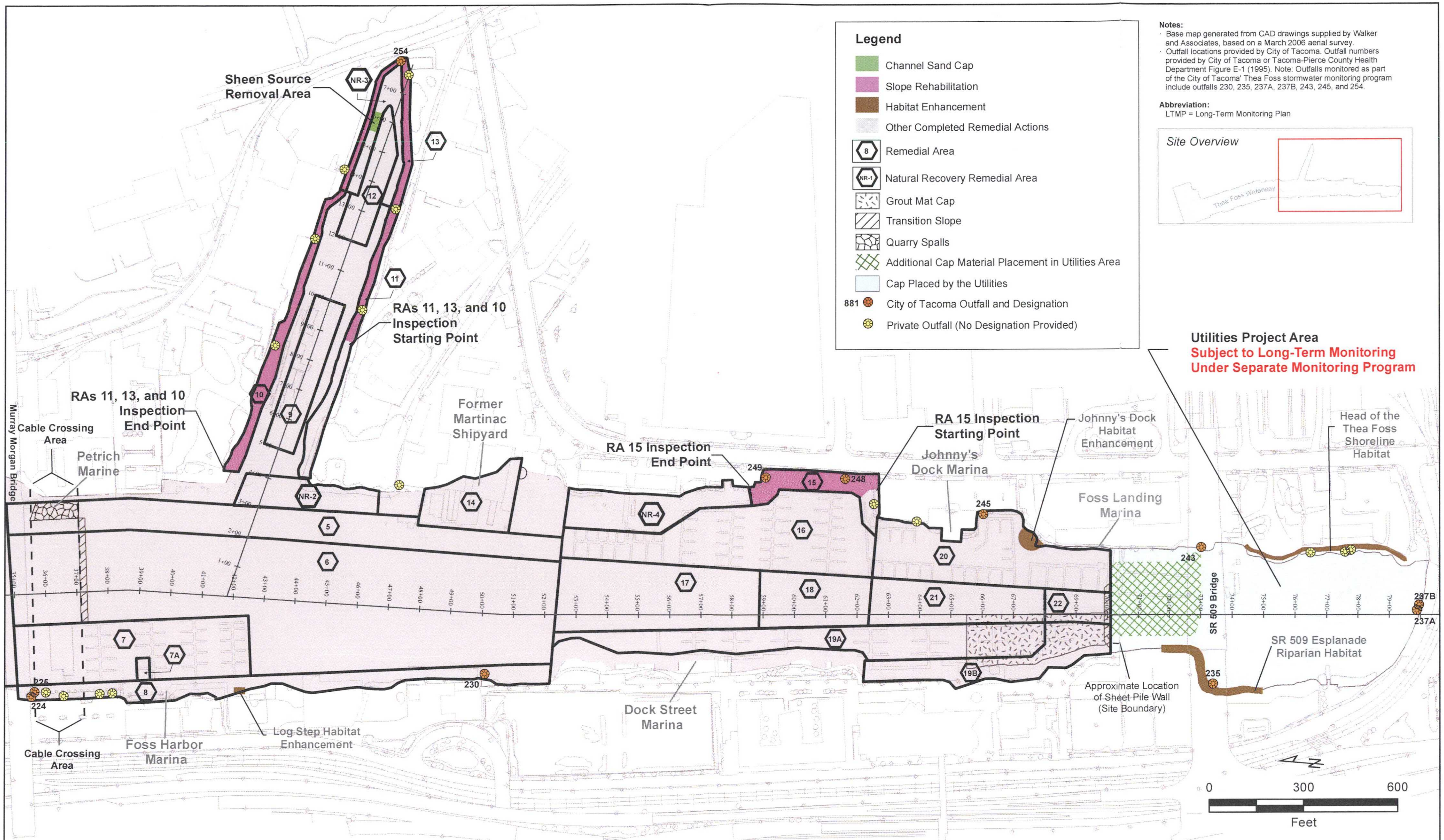
9/24/2018



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Year 12 LTMP Monitoring Event Report

Figure 5-1
Habitat Enhancement and Slope Rehabilitation Areas

File: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 5-1 Habitat Enhancement and Slope Rehabilitation Areas.mxd
Date: 9/24/2018

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Figure 5-2
North Beach Habitat

DATE: 9/24/2018
MXD NAME: I:\GIS\Projects\COT_ON_CALL\MXD\2018 Yr 12 LTMP Monitoring Event Report\Figure 5-2 North Beach Habitat.mxd

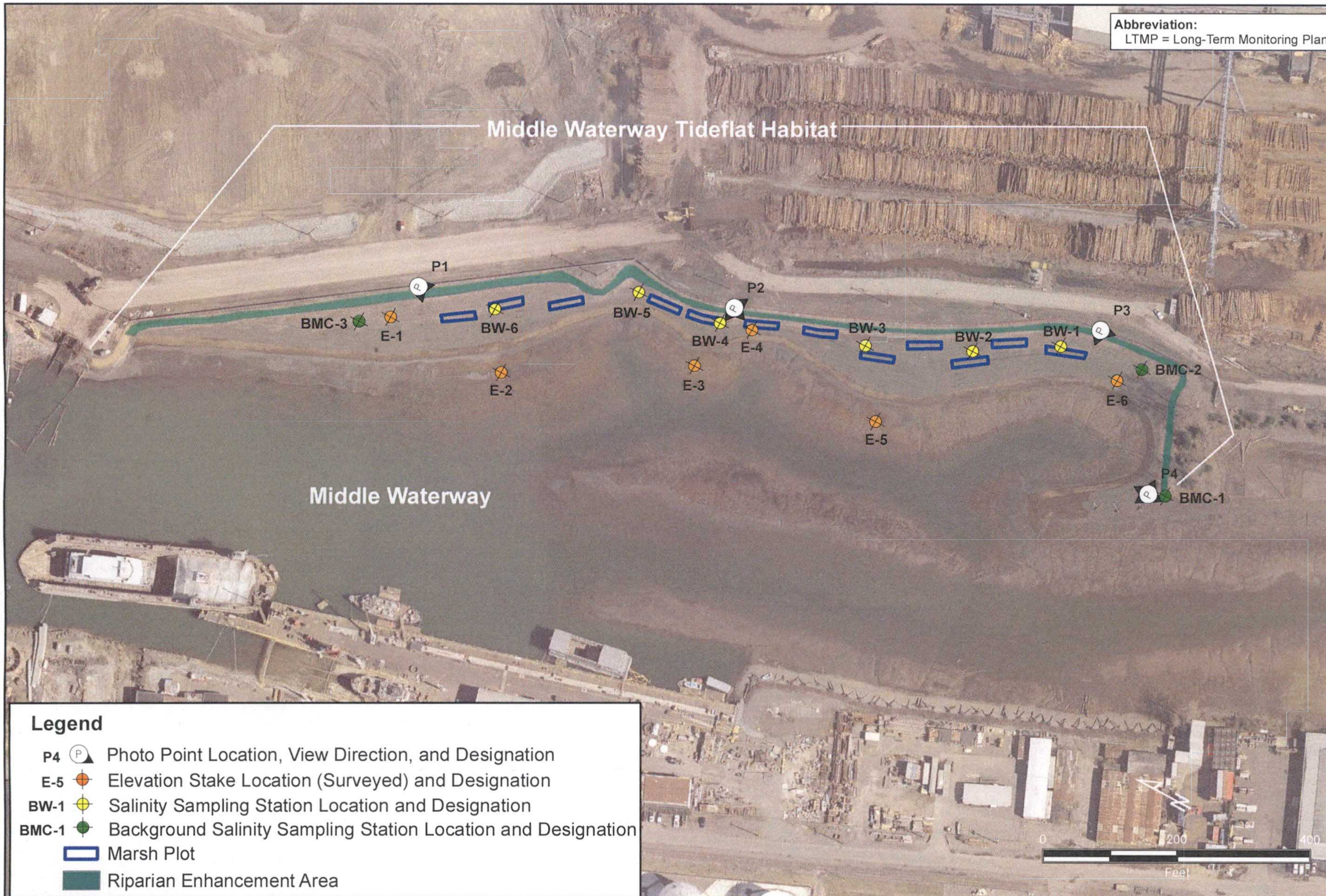

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Figure 5-3
Middle Waterway Tideflat Habitat

DATE: 006 4:19:56 PM
MXD NAME: jects\KPFF Foss\GIS\Revised OMMP\Habitat Mitigation Areas Monitoring\Figure E-6 (Middle Waterway Photo Point Locations and Sampling Station Locations) REV 121506.mxd

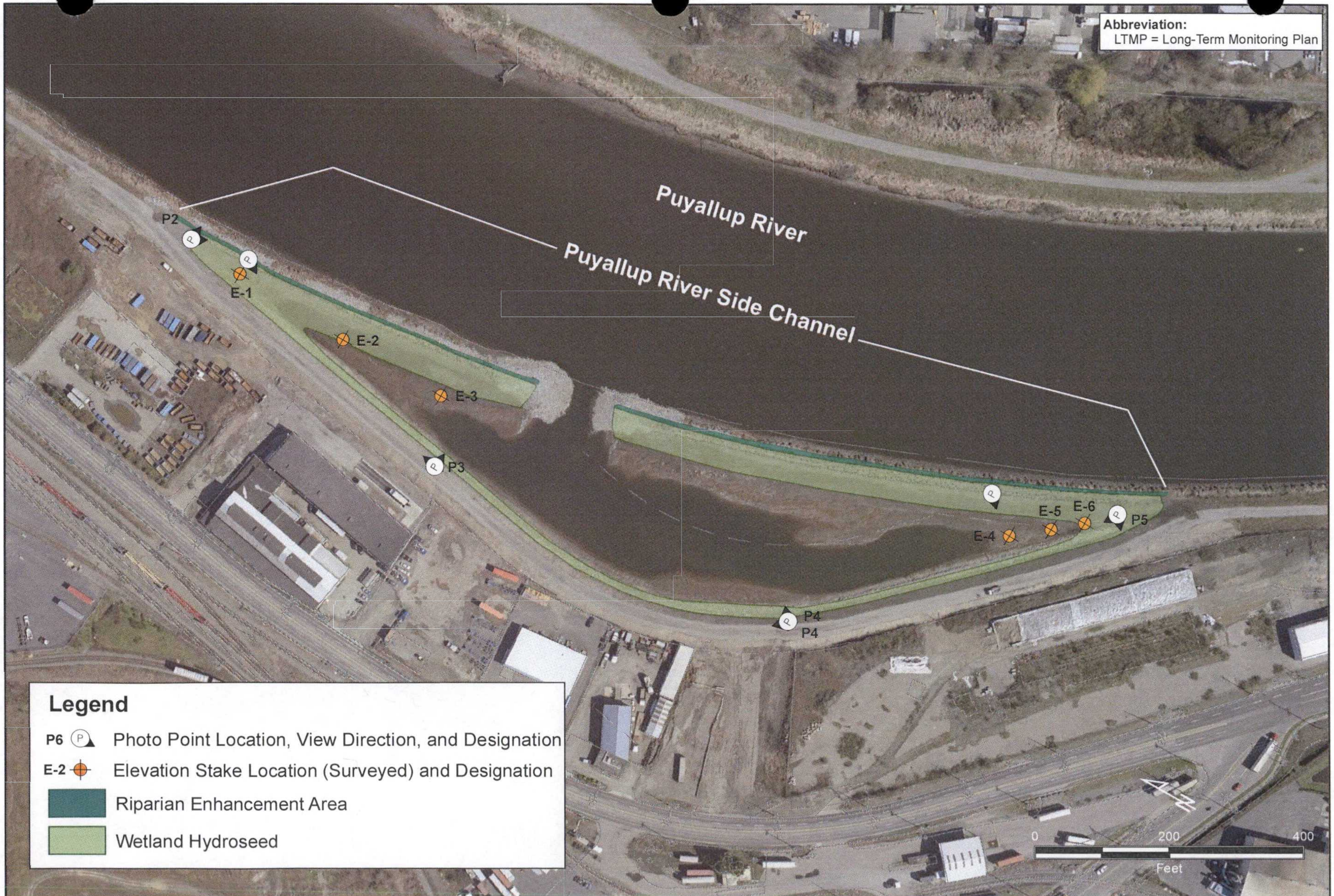

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Figure 5-4
Puyallup River Side Channel

DATE: 12/13/2006 4:40:30 PM
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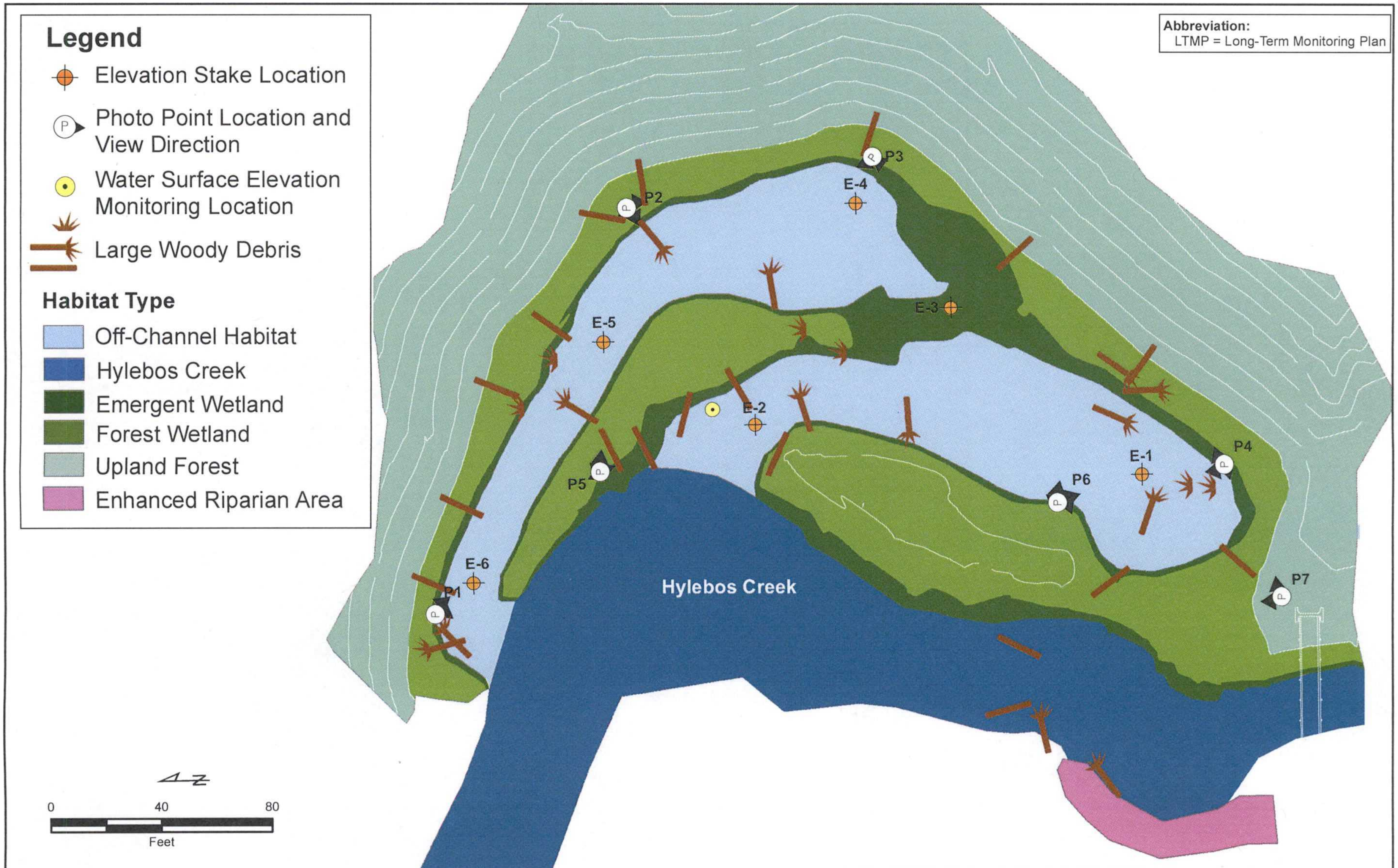

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Figure 5-5
Hylebos Creek Mitigation Site

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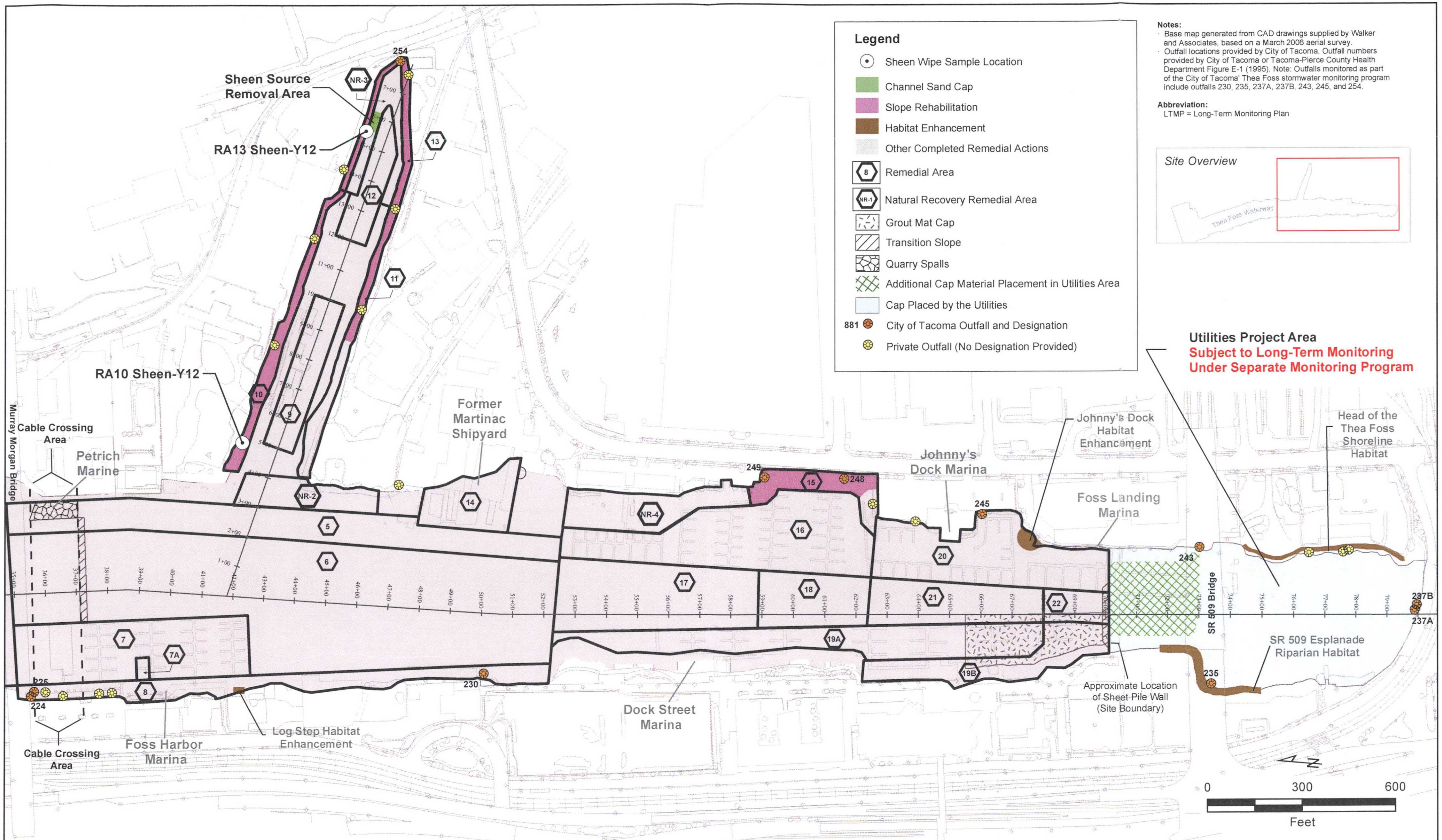

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Figure 5-6
Slope Rehabilitation Sheen Wipe Sample Locations

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Date: 10/4/2018